# HUMAN ECOLOGICAL DIMENSIONS OF CHANGE IN THE YUKON RIVER BASIN: A CASE STUDY OF THE KOYUKON ATHABASCAN VILLAGE OF RUBY, AK

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Master of Science

by
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ABSTRACT

Although the three papers that comprise this thesis analyze distinct problems they are all rooted in the study of human ecology. To that end they are based on the same data set and share the same goals. Participatory research methods involving semi-structured interviews with twenty community experts, seasonal rounds and human ecological mapping are employed to analyze the subsistence livelihoods of the Koykon Athapaskan people of Ruby Village as a manifestation of human ecological relations. Chapter 1 examines the contribution of indigenous knowledge to understandings of hydrologic change in the Yukon River and its tributaries including observations of alterations in sediment and river ice regimes. Chapter 2 considers the ethical dimensions of adaptation and vulnerability to climate change in indigenous communities who are situated within a political context influenced by a history of colonization. Chapter 3 seeks to develop a concept of water sovereignty that addresses the complex socio-cultural and ecological relations between indigenous peoples and water. The integrated perspective provided by this thesis illustrates the connections between indigenous knowledge, subsistence livelihoods, socio-cultural and ecological relations to water and the assertion of sovereignty in the face of global change.

## BIOGRAPHICAL SKETCH

Nicole Wilson grew-up in the foothills of the Rocky Mountains in Calgary, AB. Nicole completed a BA in Development Studies at the University of Calgary (2006). In her senior year, Nicole received an Undergraduate Research Award from the University of Calgary to conduct an applied research project on the Peruvian LGBTQ movement aimed at understanding how gender identity and sexuality should be addressed within international development policy and practice. After completing her undergraduate studies, Nicole held a number of positions in the field of community development. In 2006-2007, Nicole completed an internship with Canadian Crossroads International/FONCRESOL to assess the social impacts of communal banking programs in rural and peri-urban areas of the Department of Potosí, Bolivia. From 2007-2009, she had the opportunity to work as a Relationship Manager with the Agency for Co-operative Housing where she engaged in risk management for a portfolio of federal housing co-operatives in the province of Alberta. She also worked with CARA Water Resource Training Network to film a short educational video on Bolivian groundwater issues. In 2009, Nicole joined the Department of Natural Resources at Cornell to study with professor Karim-Aly Kassam. Early in her graduate studies she began working with the Yukon River Inter-Tribal Watershed Council to conduct research on the impacts of climate change and other stressors on the indigenous peoples of the Yukon River Basin. Her work has relevance at a number of levels as she aims to contribute to the formulation of policy alternatives that address issues of justice for indigenous peoples in a changing global context.

*In Memory of*

*Joseph Wright Sr.*

ACKNOWLEDGEMENTS

This research would not have been possible without the support I received from Yukon River Inter-Tribal Watershed Council, the Ruby Tribal Council and the people of Ruby Village, my research partners. There are no words fine enough to express my gratitude for their collaboration, generosity and friendship. While my thesis is complete, it is my sincerest hope that the relationships created during this research project will last a lifetime.

I am deeply grateful to the individuals from Ruby Village who shared their knowledge with me including George Albert, Phillip Albert, Tom Esmailka, Billy Honea, Clara Honea, Lorraine Honea, Junior and Karen Gurtler, Nora Kangas, Billy McCarty, Emmitt and Edna Peters, Joe Peters, Mark and Tudi Ryder, Ed Sarten, Lily Sweetsir, Pat Sweetsir, Allen Titus and Martha Wright. *Enaa baasee'.* Your contribution to this project is greater than you can ever know.

I am equally grateful to my advisor, mentor and friend Karim-Aly Kassam from Cornell University. Although I have had the privilege of knowing many fine scholars and practitioners, working with Karim during the last seven years has influenced my thinking and career trajectory in more ways than I can mention. I am also thankful to the other members of my committee – Paul Nadasdy and Todd Walter. Their guidance and support has been essential to the completion of this research project. I would also like to thank Carol Thomas (YRITWC), Jon Waterhouse (YRITWC), Ryan Toohey (YRITWC) and John Shurts (YRITWC legal counsel) for their support and comments on previous drafts of the papers that comprise my thesis.

I have benefitted tremendously from being a part of the academic community at Cornell University. The interdisciplinary environment provided by the Department of Natural Resources has challenged me to take intellectual risks that have improved the quality and complexity of my work in many ways. I have also benefited from being a part of the American Indian Program, which fosters intellectual exchange on topics pertinent to indigenous peoples, while also contributing to the creation of lasting relationships and meaningful community among undergraduate and graduate students, faculty and staff.

I am grateful to my peers for their friendship and inspiration. I would specifically like to thank the members of my research group and fellow graduate students Michelle Baumflek, Darragh Hare, Murodbek Laldjebaev, Chuan Liao and Morgan Ruelle. I am especially indebted to Michelle Baumflek and Morgan Ruelle for their comments on my thesis. I am grateful to Morgan Ruelle for his assistance with creating the template for my seasonal rounds and with Arc GIS used in creating human ecological maps for Ruby Village and to Chuan Liao for his support with statistical analysis in Chapter 1. Finally, I am thankful to my friend and long-term collaborator Jennifer Reddy for her unending encouragement and for her comments on a previous draft of Chapter 1.

I am forever indebted to Martha Wright for the tremendous generosity that she showed in welcoming me into her home in Ruby Village. I will never forget the conversations we shared over meals, countless cups of coffee and during our evening fishing trips.

This research was made possible by funding from various grants and fellowships. Specifically, I had the honor of receiving the Arctic Institute of North America, Grants In-Aid (2010), the Department of Foreign Affairs and International Trade, Canada – Circumpolar World Fellowship, (2010), the Cornell Graduate School Research Travel Grant (2010, 2011), the Mario Einaudi Center for International Studies Travel Grant (2010, 2011) and the Woodrow Wilson Fellowship Foundation's Doris Duke Conservation Fellowship (2011-2012).

Finally, I do not know where I would be today without the love and support of my family. I am grateful to my siblings Rae Spoon, Dan Wilson and Joe Wilson, whom are also my best friends. I thank my mother Brenda Buchanon for teaching me to work hard and for always believing in me. Finally, to my grandmother Dorothy Barbour who has always encouraged me to follow my dreams and to approach life with humor, even in the most difficult situations.

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# INTRODUCTION

This research project is motivated by the need to understand the impacts of climate change and other environmental stressors on indigenous communities of the Arctic and Subarctic. The chapters that comprise this work are based on human ecological research aimed at understanding the complex social and environmental issues facing the Koyukon Athabascan people of Ruby, AK and their subsistence way of life. As a researcher, I have contributed my analysis to this project. However, this work would not have been possible without the knowledge and interpretations of my research partners in Yukon River Basin and specifically in Ruby Village. It is my sincerest hope that they feel that this research also belongs to them.

Research in Ruby Village is fundamentally informed by a participatory approach. Participatory Action Research (PAR) is an iterative approach to research used to generate knowledge through cycles of action and reflection (Greenwood and Levin 2008). Furthermore, PAR is a fundamentally ethical philosophy that informs research methods and design in order that inquiry can serve as the basis for social change (Greenwood and Levin 2008). Community collaboration in all aspects of research design and implementation is vital to PAR and contributes to the goal of affecting social change (Kassam 2009). Participatory approaches are especially well suited to the study of indigenous knowledge because they integrate reciprocity, which is integral to reducing the risk that research will reproduce colonial relationships between the researcher and research participant. Moreover, the attributes of indigenous knowledge, such as context specificity and complex connectivity to socio-cultural and ecological systems make participation a necessity (Kassam 2009).

My research process began in 2009 when the Yukon River Inter-Tribal Watershed Council (YRITWC) – a treaty-based indigenous grassroots organization consisting of 70 First Nations and Tribes, dedicated to the protection and preservation of the Yukon River Basin – invited me to work with them to conduct my MS thesis research. Their support in facilitating a research partnership between the author and Ruby Tribal Council (RTC) was essential to the project. Research in Ruby Village was designed and conducted in partnership with the YRITWC in order to ensure that the project would also meet the goals of the seventy indigenous governments they work with in the Yukon River Basin (YRB). All research data and outputs were validated by and shared with the people of Ruby, RTC and the YRITWC (Figure 1).

In 2002, the YRITWC conducted a Unified Watershed Assessment (UWA) in order to document changes in the conditions of the Yukon River and its tributaries for the protection of indigenous peoples and their subsistence way of life in the YRB (YRITWC 2002). The UWA identify pollution, from municipal, mining and military waste and climate change to be the main contributors to environmental degradation. During the last decade, the YRITWC has worked to understand and address these changes using a combination of indigenous and scientific knowledge. As part of this process, the communities that they work with identified the need to document indigenous observations of the changes occurring in the YRB. This study was designed to meet this need by documenting the people of Ruby Village's observations of changes in their local ecology and the implications these changes have for their human ecological relations. While the cultural and ecological diversity that exists in the YRB means that one case study is not sufficient to understand the complex

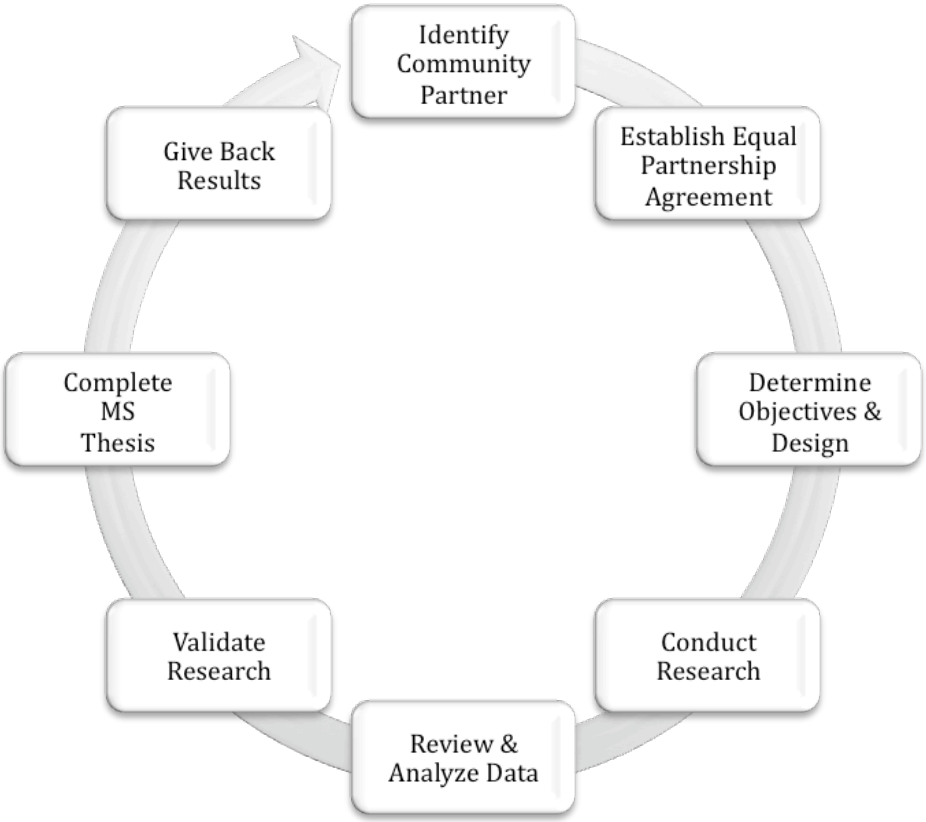


**Figure 1 Participatory Research Design depicts the author's research process carried out in partnership with the Yukon River Inter-Tribal Watershed Council and the Ruby Tribal Council**

changes that are occurring in the watershed, many of the observations of climatic variation in Ruby Village are consistent with phenomena that have been observed in other contexts.

My fieldwork began in June 2009. I spent two field seasons in the YRB from June 2010 to October 2010 and a second field season in July and August of 2011. Fieldwork consisted of conducting semi-structured interviews and human ecological mapping with 20 community experts in Ruby Village (Appendix A). Further methodological details are provided within the individual chapters of this thesis. A

public presentation was held in Ruby Village in July 2011 to share and validate the results of this research with the community.

This research has been designed to serve the needs of my research partners. First, the Ruby Tribal Council as well as individual community experts mentioned that they viewed the documentation of their subsistence livelihood practices as an immediate benefit of this research. While there have been previous ethnographic studies of the subsistence livelihoods of the Koyukon Athapaskans, there has not been a systematic studies of the subsistence practices maintained by the people of Ruby Village. The people of Ruby have acknowledged the educational value of documenting subsistence livelihoods. In addition to the copies of the thesis, community report and human ecological map that I have committed to provide to the individual community experts and the Ruby Tribal Council, copies have been requested by school in Ruby for educational purposes. Second, the YRITWC has acknowledged that the research is useful to their work in that it provides guidance for future research on the impacts of climate change on the hydrology of the Yukon River Basin and the impacts that these changes might have on the subsistence livelihoods maintained by the indigenous communities they work with.

While conducting research in Alaska, I also had the opportunity to participate in two internships with the YRITWC. I contributed to the organization in various capacities, which included supporting the Science Department with the collection of water samples for their basin wide water quality monitoring study, providing logistical support during the YRITWC biennial summit held in Ruby, Alaska in 2011 and working with a team of legal experts to examine the current state of indigenous water

rights in the YRB. Participation in these internships was an integral part of my research process as they were fundamental to increasing my understanding of the complex context of the YRB. These internships were also fundamental to building lasting relationships with the YRITWC staff, board members and the RTC. Furthermore, they represent another method of integrating reciprocity into my research process by creating a situation where I was able to immediately give back to my research partners.

My thesis describes and analyzes the human ecology of the people of Ruby. Indigenous human ecology is defined as "the relationships between people and their environment, which includes relations between humans and human relations with other animals, plants, and their habitats" (Kassam 2009, 65) (Figure 2). Indigenous knowledge is generated through the interactions that comprise their human ecological relations (Ibid). Indigenous knowledge systems emerge from long-term interactions between humans and their habitat or their human ecology. Indigenous knowledge is best described by its attributes: context specificity since knowledge is a product of specific interactions within a context; complex connectivity through myriad human ecological relations; empirical tendency since knowledge is enabled through direct observation; cumulative in that it is the product of long-term engagement passed down from previous generations and adapted to the current context; and plurality meaning that indigenous knowledge and its holders are diverse. Knowledge held by community members can vary based on a number of factors including gender, class, age, experience, personal interest and many others. It should not be assumed that all holders of knowledge *know* about the same things (Kassam 2009).

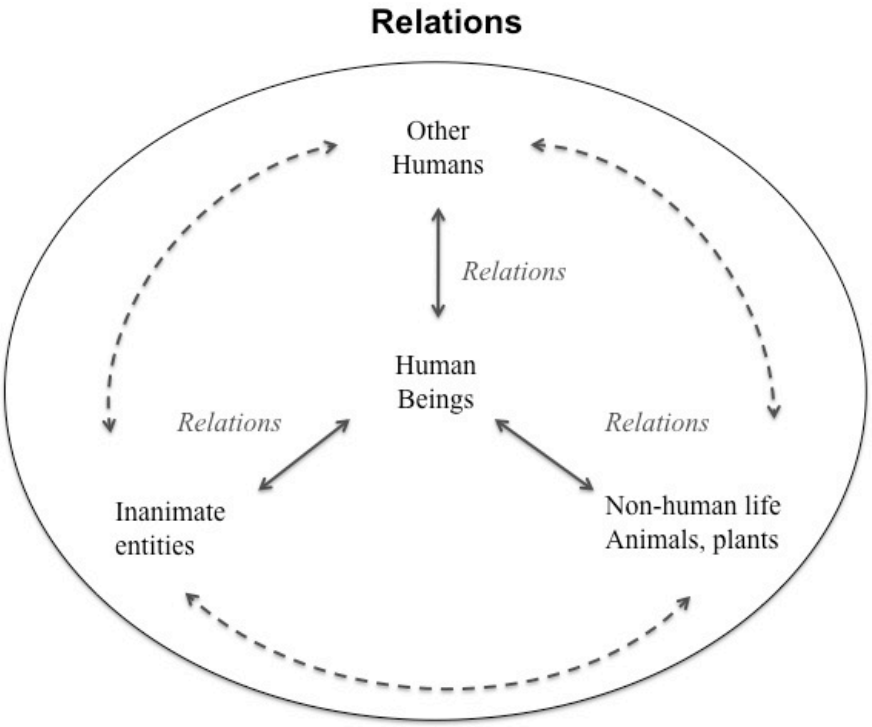


**Figure 2 Diagram of human ecological relations adapted from (Kassam 2009a)**

Indigenous knowledge systems, and the human ecological relations that inform them, can be observed through the actions of individuals and communities engaged in subsistence livelihoods. While subsistence has been defined in a number of ways, Alaska Natives conceive of their relations with the local ecology as "our way of life" or "our culture" (Wheeler and Thornton 2005). Furthermore, subsistence livelihoods are fundamentally about wealth and sharing, rather than eking out a meager living (Ibid.).

The following chapters document various aspects of the human ecology of the people of Ruby in an effort to ascertain the effects of changes in land, water and

animals as they affect subsistence livelihoods. The causes of climate change are largely beyond the control of indigenous peoples, yet these communities are among the first to observe and respond to its impacts. Given the incompleteness of climate science, indigenous observations of change have a significant role to play in understanding the impacts of climate change. The influence of climate change on the hydrology of the Yukon River is one area of particular importance for the indigenous inhabitants who rely on the river for many aspects of their subsistence livelihoods. Chapter 1 of this thesis analyzes the observations of hydrologic change contributed by indigenous community experts in Ruby Village in an effort to further understand the impacts of climate change on the Yukon River. It is also pertinent to examine how communities are adapting to the impacts of climatic changes. Chapter 2 explores the topic of climate change adaptation from a historical perspective. The people of Ruby have experienced dramatic social changes as the result of colonization between 1950s and present times. Findings demonstrate that the influence of past social changes on the present social and political context of Ruby Village have significant bearing their capacity to adapt to climate change. At the request of the YRITWC in 2011, I began to focus my research on indigenous water rights in the Yukon River Basin. Human ecological research in Ruby Village adds complexity to legal perspectives on the importance of water for indigenous peoples who maintain distinct relationships to water. These relationships are challenged by the threat of pollution and climate change. Chapter 3 seeks to develop a concept of water sovereignty capable of addressing the specific relationships to water maintain by indigenous peoples. Water sovereignty acknowledges the simultaneous need for legal rights and other elements

that create the possibility to assert these rights, including cultural choice, ecological knowledge and ecological possibility.

Although these three chapters address distinct topics, they are interrelated through their grounding in a human ecological approach to understanding the relationship between the people of Ruby and their ecology. Indigenous observations of hydrologic change and their impacts on subsistence (Chapter 1) are essential to the process of adaptation to climate change (Chapter 2). Furthermore, these observations arise from the relationship between the people of Ruby and water and land and are fundamental to their assertion of water sovereignty (Chapter 3). The conclusion of this paper links these three chapters together

# CHAPTER 1
# SOCIO-HYDROLOGY: INDIGENOUS KNOWLEDGE OF HYDROLOGIC CHANGE IN THE YUKON RIVER BASIN

## *Introduction*

Arctic and Subarctic watersheds are disproportionately realizing the impacts of climate change (Battiste and Henderson 2000; Berkes 2008; Pierotti 2010; Semali 1999). Freshwater ecosystems, located in these geographies, are sensitive to climatic changes because their habitats are dependent on complex interactions between temperature, precipitation and permafrost (Huntington et al. 2005). Increasing temperature, variations in precipitation, melting permafrost and a deepening of the soil active layer have been observed (Hinzman 2005; Osterkamp 2007). These changes are projected to result in alterations to water and sediment chemistry and discharge in upcoming decades (Schuster 2007).

Little is known about the long-term effects of these changes in Arctic and Subarctic watersheds such as the Yukon River Basin (YRB). Indigenous peoples whose livelihood strategies are closely connected to their local ecology are among the first to observe and to formulate responses to these changes (Berkes, Folke, and Gadgil 1995; Nyong, Adesina, and Osman Elasha 2007; Turner and Clifton 2009). Hydrologic change and its impacts on indigenous peoples are explored through a case study in the Athabascan Village of Ruby located in the YRB (See Figure 3).

The specific relationship between indigenous peoples and water has been acknowledged in other contexts (ICIMD 2009; Singh 2006; 2009; Toussaint et al. 2005; Shaw 2010), but the subject has received less direct attention in the Arctic and

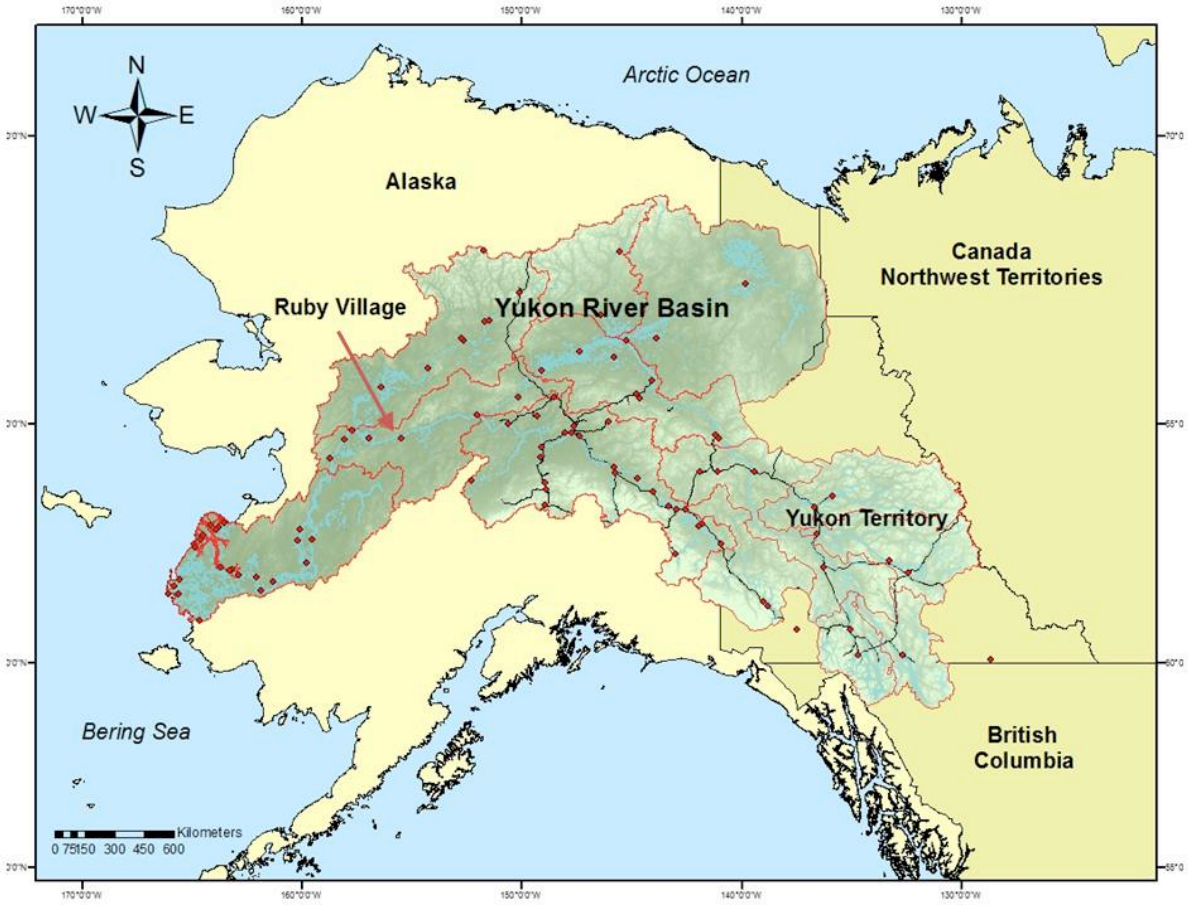


**Figure 3 Map depicts the location of Ruby Village in the Yukon River Basin**

Subarctic. Instead, indigenous knowledge of water has been addressed implicitly within a century of scholarship on subsistence livelihoods in the Arctic and Subarctic, where there is no perceived separation between land and water (e.g. the Koyukon Athabascan relationship to waters including lakes, rivers, ice and snow in Nelson 1986).

The vulnerability of Arctic and Subarctic water resources to climate change and other threats has recently been brought to the forefront (Alessa et al. 2008a). The value of indigenous knowledge in perceiving and responding to changes in water resources has also been acknowledged (Alessa et al. 2008b). Elsewhere, indigenous

knowledge of water has been referred to as ethnohydrology (Back 1981; Gartin et al. 2010). Ethnohydrology "is concerned with the science of hydrology in the broadest sense, to include both the observation and interpretation of phenomena and the application of knowledge so gained to the practical problems of water use and management by ancient peoples" (Back 1981, 258). Socio-hydrology, or the science of the interactions of people and water, is based on the assumption that social, ecological and physical sciences are essential to understanding the dynamic interactions within coupled human-hydrologic systems (Sivapalan et al. 2011). Hence, ethnohydrology can be understood as a sub-set of the study socio-hydrology, which establishes the importance indigenous knowledge to understanding hydrologic systems.

Indigenous peoples have identified climate change, in addition to other problems such as contamination originating from various sources including municipal, mining and military waste, as a major threat to water resources in the YRB (YRITWC 2002). Through an in depth study of observations of change in the hydrology of the Yukon River at Ruby Village, the contribution of indigenous knowledge to climate research in Arctic and Subarctic watersheds is examined.

*Indigenous Knowledge, Climate Science and Practical Wisdom*

Extensive discussion has taken place regarding the definition of indigenous knowledge (Battiste & Henderson 2000; Berkes 2008; Pierotti 2010; Semali 1999). However, the complexity of indigenous knowledge means that it does not lend itself to terse definition. Instead, indigenous knowledge is best described by its attributes:

Context specific; Complexly connected; Empirical tendency; Cumulative; and Plural (Kassam 2009) (Appendix B).

The relevance of local observations to research on climatic variations has been well documented over the past several decades (Kassam 2009; Krupnik & Jolly 2002; Magnuson et al. 2000; Nichols et al. 2004; Turner & Clifton 2009). It has been noted that Arctic climate science "is complicated by insufficient scientific processes and scientific knowledge and understanding of physical and ecological processes in the Arctic, and by the lack of historical baseline data against which to measure change" (Reidlinger & Berkes 2001, p.315). Indigenous knowledge can complement western science in the study of climate change in Arctic and Subarctic communities in five major areas: "1) local scale expertise; 2) as a source of climate history and baseline data; 3) in formulating research questions and hypotheses; 4) for insight into impacts and adaptation in Arctic communities; 5) in long-term, community based monitoring in indigenous communities" (Reidlinger & Berkes 2001, pp.315–316). Despite advances in climate science during the past decade, indigenous knowledge has the continued potential to contribute to understanding climate change.

The goal of combining indigenous knowledge and western science has sparked debate over the commensurability of these knowledge systems. Indigenous knowledge is often defined in opposition to western science (Battiste & Henderson 2000; Pierotti 2010). Whereas indigenous knowledge is assumed to be qualitative, intuitive and oral, western science is considered quantitative, analytical, reductionist and literate (Nadasdy 1999). However, there is no clear separation between indigenous knowledge and science. Simplistic dichotomies fail to account for the full complexity of the

relationship between these knowledges (Agrawal 1995). This is not surprising given the difficulty that scientists have encountered in distinguishing science from "non-science" (Agrawal 1995; Greenwood & Levin 2008).

The concept of *phronesis* or practical wisdom is useful in breaking down the problematic dichotomy between indigenous knowledge and western science. As applied in the context of human ecology, *phronesis* illustrates the possibility to combine various sources of knowledge in the same cycle of knowledge generation (Kassam 2009). Active relations between diverse biotic and abiotic entities contribute to the generation of *phronesis*, or practical wisdom. *Phronesis* is an Aristotelian concept meaning practical wisdom or "wisdom in action" (Aristotle 2004). Flyvbjerg states that *phronesis* "goes beyond both analytical, scientific knowledge (*episteme*) and technical knowledge or know-how (*techne*) and involves judgments and decisions made in the manner of a virtuoso social and political actor" (Flyvbjerg 2001, p.2). Unlike Flyvbjerg (2001), who views *phronesis* as a linear progression from novice to expert, Kassam conceptualizes *phronesis* as a dynamic and iterative process. In this sense, knowledge is generated through an iterative process that cycles between of *knowing-how* (context-dependent knowledge) and *knowing-that* (context-independent). While distinct, these two forms of knowledge do not form a binary opposition because they are not mutually exclusive (Figure 4). *Knowing how* and *know that* are connected in a dynamic process where *learning how*, transforms imparted, context-independent knowledge (rational analytical knowledge or *knowing that*) into inculcated, context-dependent knowledge (knowledge by experience or *knowing how*) (Kassam 2009). Indigenous peoples who engage in subsistence livelihoods exemplify

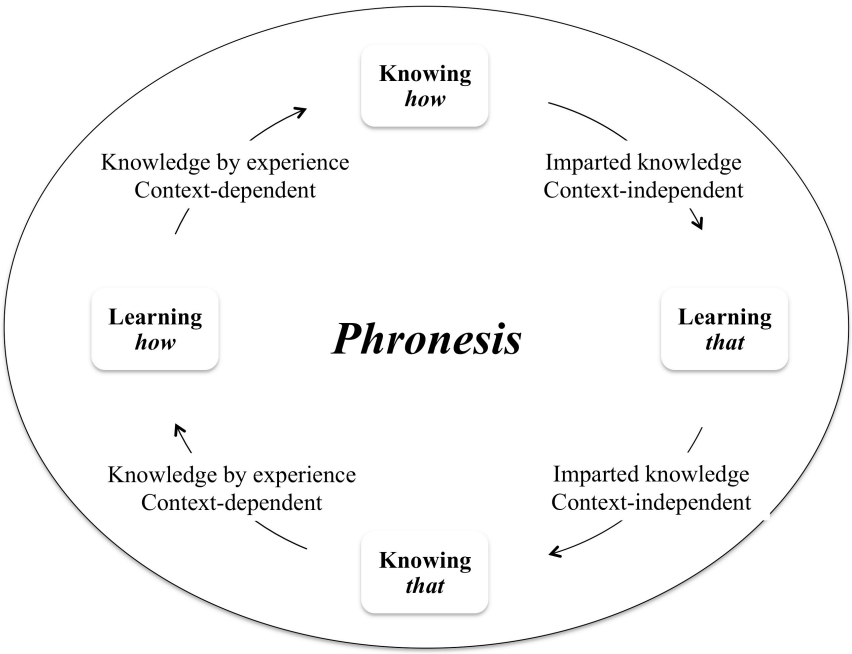


**Figure 4 Illustrates *Phronesis* as an iterative process of knowledge generation (adapted from Kassam 2009a)**

the generation of *phronesis* through engagement within diverse relations in a context. *Phronesis* is not exclusive to indigenous peoples, but also extends to the generation of knowledge in other contexts, including western scientific knowledge. Likewise, these two forms of knowledge can influence each other. For example, in the YRB indigenous knowledge holders make observations of environmental change, which are subsequently investigated by the Yukon River Inter-Tribal Watershed Council (YRITWC) using scientific methods and technologies. They call this approach 'traditional science' or "the utilization of 'best technology' guided by long-term observations of Traditional Ecological Knowledge (TEK) into particular focus areas."[1] At the same time, scientific findings can influence subsistence livelihoods practices,

[1] http://www.yritwc.org/Departments/Science.aspx

for example, water quality tests indicating that a source of drinking water is unsafe to use. While the concept of *phronesis* informs understandings of knowledge generation for both scientific and indigenous knowledge, the example above shows that they can indeed by linked in the same cycle of knowledge generation through action and reflection.

Unequal power relations between the holders of indigenous and western scientific knowledge represent a greater barrier to integration than epistemological differences (Nadasdy 1999). Existing power imbalances are between knowledge holders are largely understood as a consequence of a history of colonialism (Battiste & Henderson 2000; Smith 1999). Problematic power inequalities can influence research such that indigenous knowledge is made to conform to western scientific ways of knowing (Cruikshank 2001; Nadasdy 1999, 2005). This can occur through 'cherry picking' elements of indigenous knowledge that are compatible with a western scientific worldview, while ignoring or dismissing the rest (Nadasdy 1999, 2005). While the influence of colonial relations may be most evident in research projects involving indigenous peoples and colonial states, for example the integration of indigenous knowledge into impact assessments and co-management in the Canadian North (Ibid.), it is important to consider their influence on all indigenous knowledge research.

The value of indigenous knowledge is not only established through the incompleteness of western science (Cruikshank 2001; Kawagley 2006; Kawagley et al. 1998; Norton 2002; Reidlinger & Berkes 2001; Wenzel 1999), but it is also driven by the ethical objective to place the priorities of indigenous communities at the centre

of research agendas (Kassam 2009, p.160). The effects of climate change in the YRB are already being experienced. Other recent studies on the impacts of climate change in other Alaska Native Villages in the YRB demonstrate the value of indigenous knowledge to further understanding these complex changes (Carey 2009; Herman-Mercer et al. 2011; McNeeley 2009). This paper seeks to understand the relevance of indigenous observations of changes in the hydrology of YRB. Through a case study of the Koyukon Athabascan Village of Ruby in the YRB, we explore how indigenous knowledge of water can contribute to understanding the impacts of climate change on the hydrology of Arctic and Subarctic watersheds.

***Context***

Ruby Village is situated in the middle river region of the Yukon River (64°44'22.00"N, -155°29'13.00"W). The village is located in the Ruby Creek sub-Watershed (1,087acres) on the south bank of the Yukon River between the Villages of Tanana and Galena, adjacent to the Nowitna National Wildlife Refuge in the Kilbuk-Kuskokwim Mountains. This region, located in the interior of Alaska, has plentiful bogs, streams, lakes and sloughs, open spruce forests and shrubs and provides habitat for a rich variety of fish and wildlife including salmon, moose, diverse species of migratory waterfowl, beaver and other small game, bears and wolves (YRITWC 2002).

While the area around Ruby Village has been part of the traditional territory of the Koyukon Athabascans for millennia, the settlement itself was founded as a supply point for gold prospectors during the mining booms of 1906 and 1910 (Larson 2006). The gold strikes attracted thousands of prospectors to the area, however after WWII

most of the miners had moved away and Ruby became a native village (ADCRA 2010). Prior to residing in Ruby Village, the people of Ruby lived in the Village of Kokrines, located approximately 29 miles upriver from Ruby. Migration to Ruby Village occurred when the decision was made to close the school in Kokrines. The current population of Ruby is 166 persons, living in 62 households. The local residents are 88.6 percent American Indian or Alaska Native (U.S. Census 2010).

The Yukon River and its tributaries are defining features of the landscape, and are interconnected with all aspects of the lives and livelihoods of its indigenous residents. Water is central to subsistence livelihoods (for example, as habitat for fish). Villages and towns in the watershed obtain their water for drinking and other domestic uses from the Yukon River and related aquifers (Brabets et al. 2000). The people of Ruby are engaged in a reciprocal relationship with the Yukon River, where the River is not only seen as a means to meet their subsistence needs, but is understood to have consciousness and needs to be treated with respect (Nelson 1986).

The Yukon Territory, Canada and Alaska, USA have been described as a 'Republic of Rivers,' acknowledging the fundamentality of hydrologic connectivity to social interaction in the region, before and continuing after European colonization (Murray 1990). For example, river networks were and continue to be an important transportation corridor for villages, which are not located on the roads system. Water is used for transportation year round. During the ice-free season people travel by boat and when the rivers are frozen they are used by people travelling on snowmobile or by dog sled. Changes to the hydrology of the YRB have serious implications for the lives and livelihoods of the people of Ruby. This case study therefore documents

indigenous observations of change in the Yukon River at Ruby in an effort to understand the impacts of climate change on the hydrology of the YRB.

***Methodologies***

Participatory Action Research (PAR) is an iterative approach to research used to generate knowledge through cycles of action and reflection (Greenwood and Levin 2008). Furthermore, PAR is a fundamentally ethical philosophy that informs research methods and design in order that inquiry can serve as the basis for social change (Greenwood and Levin 2008). Community collaboration in all aspects of research design and implementation is vital to PAR and contributes to the goal of affecting social change (Kassam 2009). Participatory approaches are especially well suited to the study of indigenous knowledge because they integrate reciprocity, which is integral to reducing the risk that research will reproduce colonial relationships between the researcher and research participant. Moreover, the attributes of indigenous knowledge, such as context specificity and complex connectivity to socio-cultural and ecological systems make participation a necessity (Kassam 2009).

This research project strives towards the ideal of PAR. The study can be characterized as participatory in the sense that it was designed and conducted in partnership with the Yukon River Inter-Tribal Watershed Council (YRITWC), whose goal is to meet the needs of the seventy indigenous governments they serve in the Yukon River Basin. Furthermore, the YRITWC facilitated a research partnership with the Ruby Tribal Council (RTC) and the project was modified to fit the context of Ruby Village. All research data and outputs were validated by and shared with the RTC and the YRITWC (Figure 5). Working directly with community members to determine

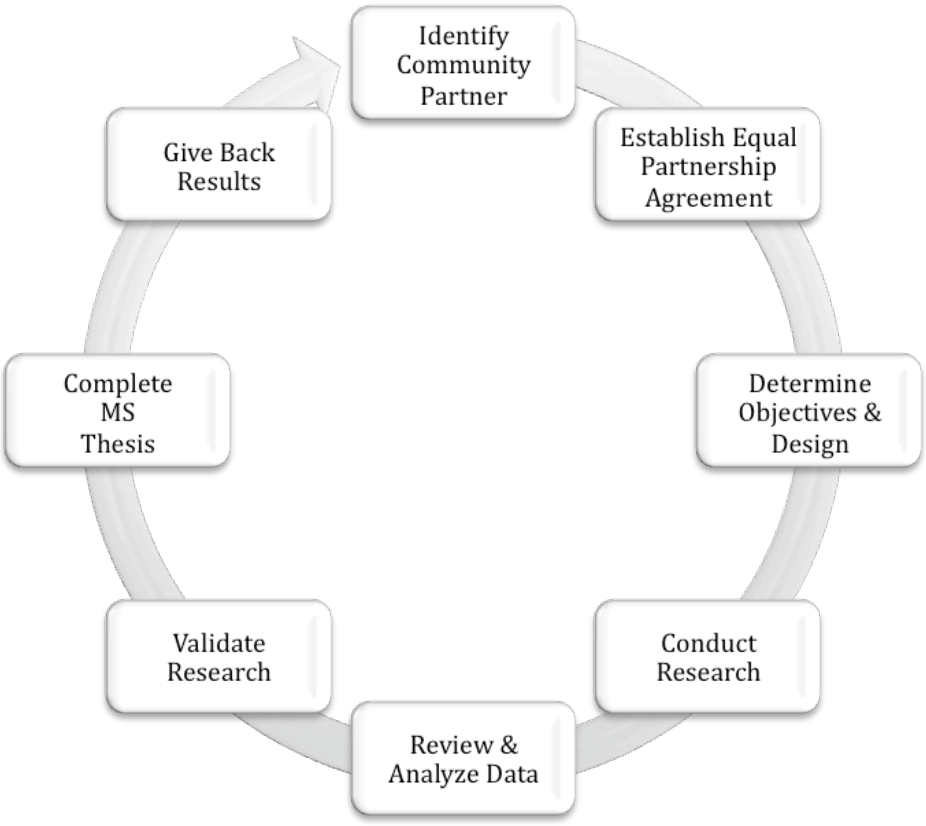


**Figure 5 Participatory Research Design depicts the author's research process carried out in partnership with the Yukon River Inter-Tribal Watershed Council and the Ruby Tribal Council**

research objectives and design, rather than just the YRITWC, will strengthen future attempts at participatory research. Research was conducted during two field seasons. The first of these field seasons took place between June and October 2010 and the second in July and August 2011 (Figure 6). During this time, semi-structured interviews were conducted with 20 community experts, including Elders, subsistence harvesters and tribal administrators.[2] This included eight women and twelve men whose ages ranged from 49 to 92 (Appendix A). Community experts were recruited

[2] Community experts were selected based on recommendations from other members of the community. Each of the community experts was heavily involved in subsistence practices and had lived in Ruby for an extended period of time, if not their whole life.


**Figure 6 Conveys the iterative research process followed when conducting research in Ruby Village. Each community expert was visited a minimum of three times over the course of five research trips to Ruby Village.**

using a snowball method where contacts at the Ruby Tribal Council were asked to make a list of the individuals who could contribute to the research (Patton 2002). Community experts were added to the initial list when referred by individuals who had already participated in the study.

Interviews were conducted using an iterative process. A minimum of three meetings was held with each community expert.[3] During an initial interview, community experts were asked to describe their subsistence livelihoods and

[3] All community experts were visited a minimum of three times. However, at the request of the community experts additional visits were paid and further information was added to interview narratives as needed.

observations of social and ecological change. Specific follow-up questions were asked to clarify responses. Interviews were documented using written field notes rather than audio recordings. The author wrote a narrative essay based on interview field notes. Typed versions of interview narratives were validated during a second interview. Interview narratives were read out loud to the community expert. At the time of validation, changes were then made to interview narratives to correct data or to add other important information that was left out during the initial interview. During a third visit, final printed versions of final of interview narratives were given to each participant for their records.

Interview narratives were coded for observations of change using Text Analysis Mark-up System (TAMS) Analyzer, a qualitative data analysis tool. All observations that could be linked to the impact of climate change on hydrology were included. The number of experts, out of the twenty total, who observed a given phenomena are noted in brackets. The interpretation of this research was then shared with the community for validation during a public presentation in Ruby Village in July 2011. Community experts consented to having their names used in this research. Their names are used as a form of citation and to recognize the contribution their knowledge has made to this research.

***Results and Discussion***

Research findings indicate that the impacts of climate change are already being observed. Community experts contributed observations of hydrologic change gained through long-term engagement with the local ecology through subsistence livelihoods. Their observations are analyzed in the following section, in relation to findings from

western scientific literature on climate change in Arctic and Subarctic freshwater systems, in an effort to understand hydrologic change in the YRB.[4]

*Variability*

The climate of the YRB is characterized by high variability (Hare & Mantua 2000; Hartmann & Wendler 2005). According to Elder Lorraine Honea, the natural variability of the Yukon River "has always driven people here crazy." However, other community experts also note that the river is even less predictable than it used to be. Elder and traditional chief Billy McCarty stated, these days "we can't predict what the heck it [the Yukon River] will do." An increase in weather variability is supported by the scientific literature (ACIA 2005; Hinzman 2005). This includes more acute climatic events such as temperature and precipitation extremes (Easterling et al. 2000).

Though human induced climate change is certainly a significant factor contributing to increased variability, the influence of other factors must also be considered. The decadal change associated with Pacific Decadal Oscillation (PDO), which causes decadal shifts in climate averages, also contributes to this variability (Salinger 2005). Temperature records for the interior of Alaska indicate high interannual and high interdecadal variability. The Alaska temperature record indicates a warming trend that started in the winter of 1976-1977 (Figure 7) and corresponds with a regime shift in PDO, which alternates between warm and cool phases approximately every 20 to 30 years (Hare & Mantua 2000; Hartmann & Wendler 2005). There is evidence that this most recent PDO warming shift ended in 1999,

[4] The use of semi-structured interviews means that each interview was unique and not all the community experts were asked the same questions. Therefore, the number community experts who mentioned a specific observation of change cannot be used to infer quantitative results.

however global warming trends continue at unprecedented rates (Salinger 2005). The PDO must be taken into account when discussing the possibility that human-induced climate change is increasing variability.

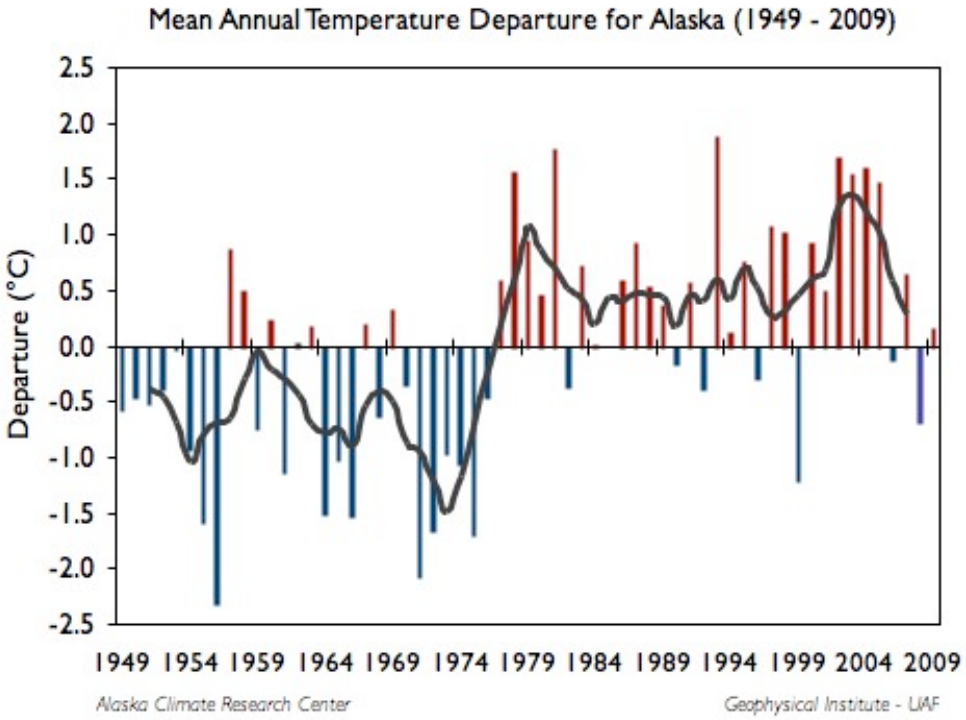


**Figure 7 Mean Annual Temperature Departure for Alaska ($^0$C) 1949-2009 demonstrates an increase in 1976-1977 that corresponds to the Pacific Decadal Oscillation shift from cool to warm (ACRC and GI, UAF 2011).**

*Increases in Air Temperature*

All community experts noted a marked increase in temperatures in their lifetimes, with the largest increases in recent decades (20/20). They observed that they hardly get any days below -45$^o$C (-50$^o$F) anymore. According to Lorraine Honea, an elder who was 90 years old at the time interviews were conducted,

> Winter used to get to about 70$^0$F below. I remember it going as low as 78$^0$F below in the winter in the 1930s. Some say that winter it froze dog tails off, but maybe they didn't have enough grass to keep them warm. In Fairbanks at her house, the lowest it got this winter was -40$^0$F. The weather hasn't gone below 60$^0$F for a couple of years.

Historical temperature records for Ruby Village are available for Ruby Village between 1935 and 1939. The coldest temperatures on record during this decade occurred in December, 1939 ($52^0$F below) and January, 1939 ($53^0$F below) (U.S. Department of Agriculture, Weather Bureau 1935). While temperature records do not seem to correspond to the extreme temperatures observed, there is value to the general observation that temperatures are not as low as they used to be during the winter months.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) concluded that 11 of the last 12 years are the warmest on record since instrumental observation began in 1850, and that the average temperature of the Earth has increased by 1.3°F (0.74°C) over the past 100 years (IPCC 2007). Mean temperature increases demonstrate that Arctic regions of Alaska and Western Canada are among the fastest warming regions in recent decades (ACIA 2005; Hansen et al. 2006). Climate data from the interior region of Alaska, characterized by a continental climate, where the majority of the YRB lies, has shown some of the most marked warming statewide over the last six decades (ACRC and GI, UAF 2010). Instrumental observations indicate that Alaska's mean annual temperature increased 1.7°C (3.0°F) from 1949 to 2009, with local wintertime mean temperature change that range from 4.1 to 4.9°C (7.4°F to 8.9°F) in the interior region (ACRC and GI, UAF 2010) (See Figure 8). Larger changes are projected over the next century (ACIA 2005). Temperature is a major driver of hydrologic change and other observations below indicate the Yukon River is already affected by the observed increases.

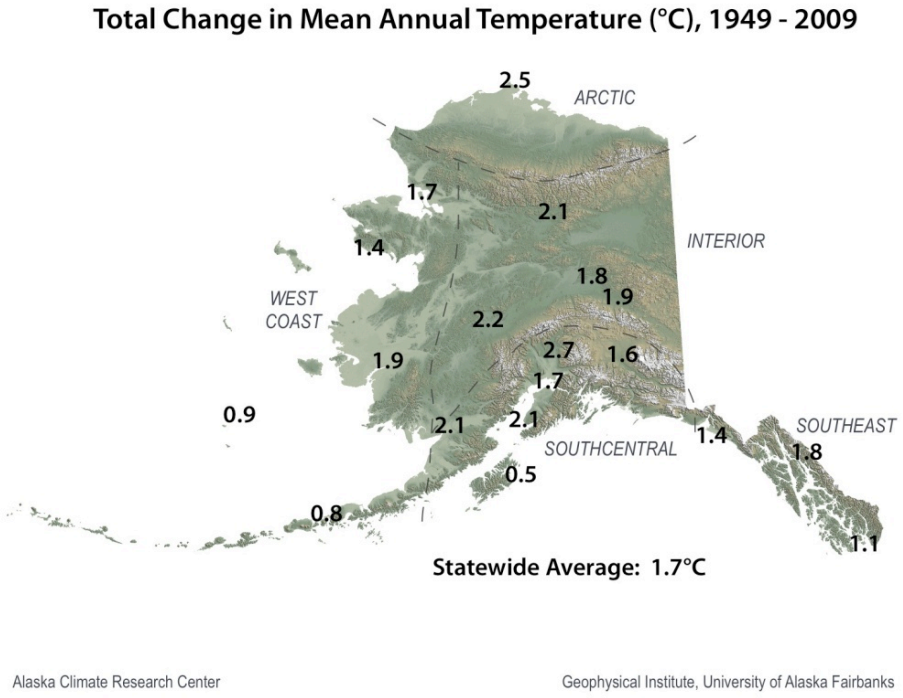


**Figure 8 Illustrates the Total Change in Mean Annual Temperature ($^0$C), 1949-2009 (ACRC & Geophysical Institute 2010). Figure demonstrates that some of the most marked increases in temperature are occurring in Alaska.**

*Changes in Precipitation*

Community experts perceived changes in precipitation, in the form of rain and snowfall (20/20). While one community expert observed that rainfall was decreasing, leading to an overall drying of the landscape, many community experts noted an overall increase in rainfall. Community experts also observed that while it normally rains the most in August, the rain is now arriving at strange times, for example it is raining more in July when it is usually dry. A decrease in snowfall during the fall and winter months was observed. The area around Ruby receives less snowfall overall and snow seems to be arriving later in the season. Billy McCarty commented:

> There seems to be a lot of rain. It is raining off and on. The snow is unpredictable. Years ago we used to pretty much know how much we would

> get. The past 15 years we don't know what we will get and this past winter they didn't get any.

Trends in precipitation are more difficult to observe than temperature because of the limitations in measuring snow and rainfall in cold environments (McBean et al. 2005). Instrumental observations for Alaska show an overall increase in precipitation during the last century, with greater increases in the fall and winter (ACIA 2005; Serreze et al. 2000). However, the overall percentage of annual precipitation in the form of snowfall has decreased (McBean et al. 2005; Stone et al. in Hinzman 2005).

Satellite measurements, beginning in the 1960s, provide a record of snow cover (Walsh et al. 2005). Satellite data are limited in its ability to measure snow depth and water equivalent (Ibid.) Data indicate in the Northern Hemisphere spring snow cover has declined 2 percent per decade since 1966, with little change in fall or early winter (Lemke et al. 2007). Overall snow cover extent has declined about 10 percent in the past 30 years and additional decreases of 10 to 20 percent are projected by the 2070s (ACIA 2005). Snow cover is an important element in cold climate systems because of its extent, seasonal amplitude, high albedo and low thermal conductivity. As a result, decreased snow cover, along with reduced sea ice extent elsewhere in the Arctic, is expected to contribute significantly to polar amplification of climate change (Serreze et al. 2000).

Changes in annual snowfall have a significant effect on freshwater arctic ecosystems where snowfall is the most important hydrological input (Wrona et al. 2006). This could result in lower water levels in lakes and wetlands and reduced streamflow in rivers during the summer months. Reduced snowfall affects freshwater

species because it can cause changes in the chemistry and temperature of freshwater ecosystems including lakes, wetlands and ponds (e.g., pH, dissolved oxygen, dissolved carbon). These changes could have long-term negative effects on the ecology of the YRB, including regions such as Interior Alaska that are dominated by wetlands (McBean et al. 2005).

*Changes in Permafrost*

Several community experts commented that they had noticed the permafrost shifting (5/20). Those who noticed changes in the permafrost made the observation that melting permafrost might be responsible for observed shifts in buildings and changes in the roads around the Village. However, there are other factors that could be contributing to these changes. For example, community experts noted that shifting foundations could also be due in part to substandard construction.

Permafrost temperature regime has been cited as a sensitive indicator of decadal to centennial climatic variability (Lachenbruch & Marshall 1986; Osterkamp 2005). Recent trends in temperature indicate that in interior of Alaska permafrost warmed 0.5 to $1.5^0$ C from 1983–2003, at a depth of 20 meters (Osterkamp 2005). The permafrost base has been thawing at a rate of 0.04 m $yr^{-1}$ in Alaska since the 1960s. Permafrost degradation is leading to changes in land surface characteristics and drainage systems. Subsidence of the ground surface as ice-rich ground melts and forms thermokarst resulting in dramatic changes in ecosystems, landscape and infrastructure (Lemke et al. 2007). While a significant portion of the YRB lies within an area of continuous permafrost, the site where Ruby is located is characterized by isolated patches of permafrost and the areas where the majority of subsistence

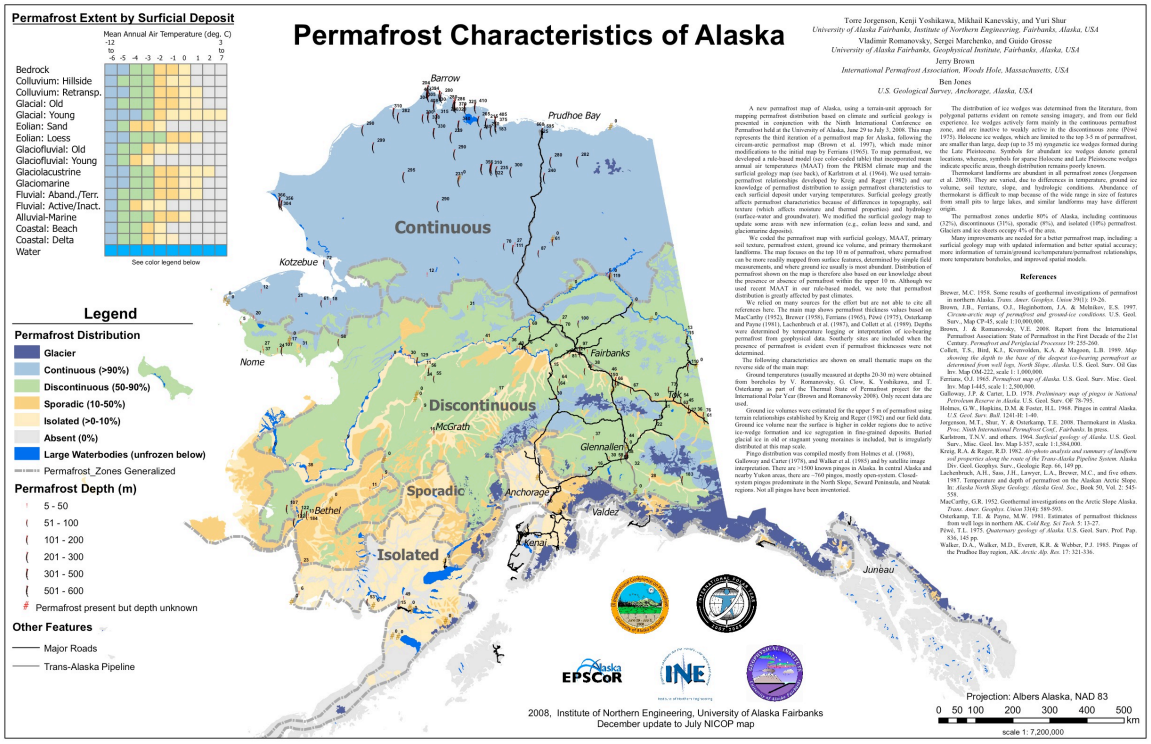


**Figure 9 Map of permafrost characteristics of Alaska illustrates that Ruby Village is located in an area of sporadic permafrost and their traditional territory is characterized primarily by discontinuous permafrost (Jorgenson et al. 2008).**

harvesting takes place are located in areas of sporadic and discontinuous permafrost (Figure 9). Though permafrost that lies outside areas of continuous permafrost is also affected by warming temperatures, fewer observations of change might, at least in part, be explained by the location of Ruby Village and the traditional territory of the people who reside there in a region characterized by discontinuous, sporadic and isolated permafrost.

The degradation of permafrost has implications for other aspects of the hydrologic regime of the YRB. Permafrost degradation affects surface hydrologic processes in a number of ways including decreased summer and increased winter streamflows changes in stream water chemistry, and other fluvial geomorphologic processes (McNamara et al. 1998). Many of the observations of change listed below

may be connected to changes in permafrost and its impacts on groundwater flows throughout the YRB. For example, several community experts also observed increases in River bank erosion (3/20). Although respondents did not attribute this change to melting permafrost, there is evidence that melting permafrost may be the cause of increased erosion (ACIA 2005).

*Changes in Freeze-up, Break-up, Ice Coverage and Thickness*

Community experts observed changes in river ice regimes including alterations in freeze-up, break-up and the general characteristic of river ice coverage and thickness. The timing of freeze-up has always been variable. However, most community experts observed that freeze-up on the Yukon River and its tributaries is occurring later and it is taking longer to freeze solid. This change is likely due to warmer fall temperatures (15/20). Emmitt and Edna Peters stated:

> It used to be cold. It used to be -20$^0$F around Halloween, but now it is warm in October and it doesn't freeze until late November or December. October is pretty warm so it is freezing later. It is not safe to cross the river until after Thanksgiving.

It was also noted that once the ice begins to freeze, it takes longer before it to be safe to cross either on foot or in a vehicle, typically a snowmobile.

Community experts observed that break-up seems to be occurring at approximately the same time on the Yukon at Ruby Village (4/20),[5] but several of the qualities of the event have changed (14/20). Lily Sweetsir stated,

> [t]here has been a change in spring break-up on the Yukon. It goes out at the same time in May, but the difference is in the ice. The sound it used to make

[5] Four out of twenty community experts specifically mentioned that the timing of break-up had not changed. Only one out of twenty specifically stated that break-up is occurring two to three days earlier. The remaining community experts who observed changes in break-up did not specifically mention a change in the timing of break-up (9/20).

was tremendous. Now it doesn't make that noise.

Similar to Lily, other community experts noted that break-up is happening faster and it does not make the same sound that it used to when the ice goes out.

The majority of community experts observed decreased ice thickness on the Yukon River. As a consequence, there is an increase in open leads, or places on the river that are open and remain ice free throughout the winter (16/20). The snow covers these open leads and makes it dangerous to travel on the frozen river. Billy McCarty observed,

> warmer weather can make it dangerous out on the river for travel early in the winter. The river melts then it snows and covers the holes. Now we have to wait until early December to go out on the river to trap, to get wood or just to cross the river. There is a lot of change in that. You used to be able to cross right after the ice stops. It will be moving along and then it all stops. It used to be 2 to 3 days after that you could cross. Now the ice is not that thick. There are more open spots and you have to work to get around them so you can't get over right away. You have to be really careful nowadays. You have to wait until it freezes all the way.

Overall, community experts observed that river ice thickness is decreasing and there is an increase in open leads. Martha Wright noted the influence of snowfall on ice formation. She observed if the snow falls on the ice before it has thickened it would remain thin because the snow insulates the ice. The combination of later freeze-up, thinner ice and more open leads pose serious challenges to subsistence livelihoods, which requires the river ice for travel and other activities.

In contrast to lake ice, river ice has rarely been used as an indicator of environmental change. This is likely due to the complexity of hydroclimatic factors controlling river-ice processes. There have been a number of recent studies conducted on the impacts of climate-induced change on river ice regimes (Goulding et al. 2009; Janowicz 2010; Prowse et al. 2010). Most of these studies pertain to ice-cover dates

(freeze-up and breakup) rather complex variables such as ice thickness, or ice-jam frequency and severity (Beltaos & Prowse 2009). River-ice formation occurs when the average flow temperature has been reduced to the freezing point and an initial surface layer forms from an accumulation of frazil ice forms (Beltaos & Prowse 2009). Once the first ice cover is formed across a river cross-section, freeze-up proceeds upstream through the accumulation of incoming dynamic ice forms. Ice thickness depends on a number of factors. Snow accumulation on the ice surface can dramatically slow ice growth (Ibid.).

Long-term records of freeze-up and breakup dates have been kept in many locations because of their importance to human activities. These records can provide important climatic data but must be interpreted with care because of the influence of a myriad of factors can affect both freeze-up and breakup dates including the occurrence of heavy rains upstream etc. (Lemke et al. 2007). Break-up and freeze-up records are available from the National Weather Service, Alaska, for the Yukon River at Ruby during the period of 1911 to 2011. Although the majority of community experts did not observe significant change in the timing of break-up, long-term records show a trend towards earlier break-up, which is occurring approximately five days earlier than it did in 1911 (Figure 10). Freeze-up records are consistent with observed trends towards later freeze-up and indicate that freeze-up is occurring approximately ten days later (Figure 11).[6] There are no long-term ice thickness data available for the Yukon River at Ruby with which to compare interview narratives. The timing and severity of break-up and resulting ice-jam flooding depend on a many factors, primarily driven by

[6] Figures 8 and 9 created by Chuan Liao.

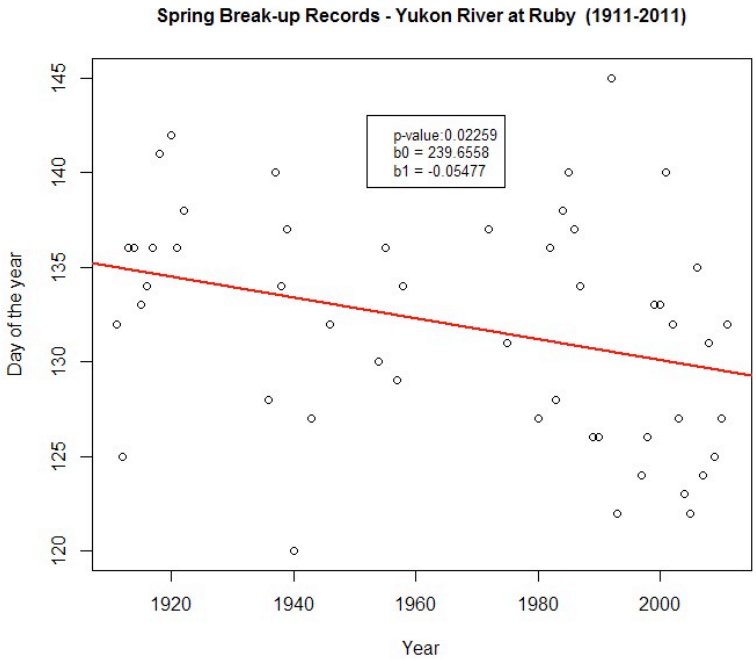


**Figure 10 Spring Break-up Dates - Yukon River at Ruby Village (1911-2011). Shows a trend towards earlier break-up, with the event occurring an average of 5 days earlier (NWS 2010a).**

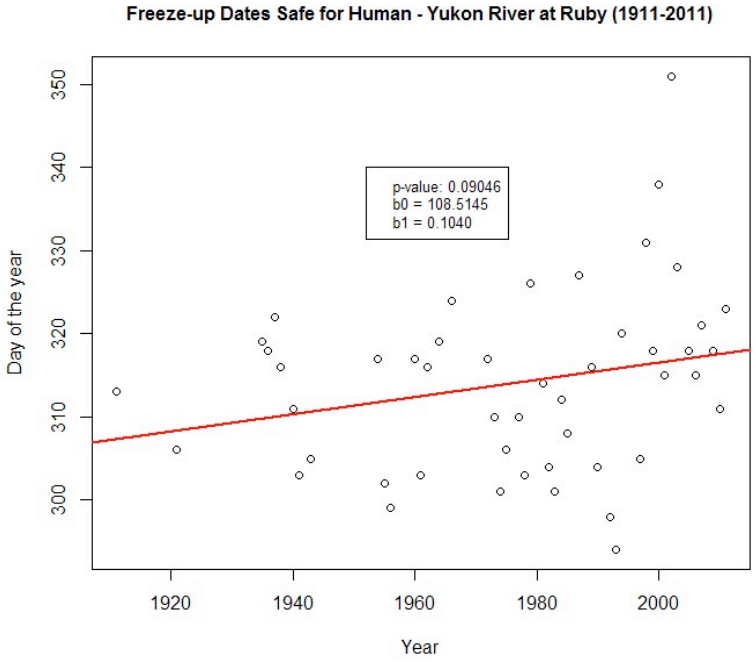


**Figure 11 Freeze-up dates safe for human to cross - Yukon River at Ruby Village (1911-2010) indicate that freeze-up is occurring an average ten days later (NWS 2010b).**

climate, but interacting with other biophysical processes (Prowse & Beltaos 2002). These factors and processes vary greatly over spatial and temporal scales (Prowse et al. 2007). As a result, these hydroclimatic controls are complex and cannot be understood as a simple observed relationship between air temperature and the timing of break-up (Prowse et al. 2010). A Canada-wide study of river freeze-up, breakup and ice duration was conducted based on records spanning 50 years or less, which indicated there was a major spatial distinction between Eastern and Western Canada. Western sites, including the Yukon River, tended towards earlier break-up dates (Zhang et al. 2001). In contrast to other studies that indicate freeze-up dates are occurring later (Lemke et al. 2007), Zhang et al (2001) found that there was an overall trend towards earlier freeze-up dates. This difference could be the result of spatial variability or due to differences in periods of record (Beltaos & Prowse 2009). Although ice thickness has been studied to a lesser extent, research shows that there is a general trend towards decreasing ice thickness, which results in more open leads (ACIA 2004).

As mentioned above, research findings indicate that there is a need for further research on two others aspects of break-up: First, break-up is completed in less time than before. Second, changes in the acoustic dimensions of break-up have been observed. Community experts observed that it no longer makes the 'tremendous sound' that it used to. These two observations have not been noted elsewhere in the literature on river ice regimes and therefore merit further investigation. It is possible that these changes indicate an alteration in the morphology of the river ice on the Yukon at the time of break-up. A change in ice morphology could be due to an

increase in thermal break-up prior to mechanical break-up. In thermal break-up, warmer temperatures decay river ice making it weaker when actual mechanical break-up, or the physical force of ice and water rushing downstream, occurs. When thermal break-up has occurred to a large extent, the break-up event is less intense as ice breaks into small pieces and no ice jams form during mechanical break-up (Rundquist 2009). A change in ice morphology at the time of break-up, due to an increase in thermal break-up, is one possible explanation for the observed changes in the timing and acoustic aspects of break-up. However, further research is required to determine if this is the case.

The observed change in freeze-up, break-up and river ice thickness and coverage are predicted to increase as Arctic and Subarctic regions experience further impacts of climate change (ACIA 2004). The projected changes in river ice regimes have a number of potential impacts on the physical, biological and chemical composition of the YRB. Changes in the timing of freeze-up and break-up and the severity of break-up can alter the natural hydrologic extremes including floods and low flows. Less flooding, related to changes in break-up is predicted in the spring. For example changes in the intensity of break-up could alter the formation of river channels and the amount of suspended sediments carried to the ocean (ACIA 2004). Biological and chemical changes are also predicted. A change in break-up intensity would affect the supply of floodwater organic carbon and nutrients to riparian zones and river deltas. These changes will also have implications for human activities. Rivers are vital transportation corridors and are used as ice roads in many areas, mostly for extractive industries (ACIA 2004). In Ruby, river ice is crucial to

subsistence livelihoods and alterations in break-up, freeze-up and ice thickness can impede travel and to access certain resources.

*Changing River Streamflow, Currents and Sediments*

Community experts have observed changes in streamflow, currents and sediments on the Yukon River at Ruby (16/20). To some extent these are always changing. However, many community experts observed that the Yukon River is getting shallower in some areas and sandbars are forming where they did not used to be. For example, there is a newly forming sand bar building up at the mouth of Ruby Slough that will eventually block it off completely. Erosion is also increasing in some areas. This may be due to stronger currents or some other factor such as melting permafrost. Billy McCarty describes some of these changes in the Yukon River:

> The river is flatter, shallower and sand bars are all over where they never used to be. The river is cutting the banks. Some of the native allotments are losing their ground because of it. One of my native allotments has lost 50 feet or so in the past 20 years. There have been a lot of changes in the channels. The water is going odd ways, different ways. It never used to go those ways.

The interaction between streamflow, currents and sediments may be linked to climate change in several ways.

Streamflow trends in the YRB indicate that flows have increased in the Yukon River (Brabets & Walvoord 2009). Streamflow records (>30 years) in the YRB show increased groundwater contributions. Increased streamflow is likely a consequence of thawing permafrost (Walvoord & Striegl 2007). Community experts observed a decrease in summer and fall water levels, in July, August and September when salmon fishing takes place and during the moose season. Earlier spring snowmelt, as a consequence of the contraction of the cold hydrologic season, is a contributing factor

to reduced flow in summer and early fall (Brabets & Walvoord 2009; Déry et al. 2009).

Observed changes in sandbars and sediments could be caused by several factors. Similar observations of changes in sandbars and sediments were also found in an indigenous knowledge study conducted in the lower river region of the Yukon River (Herman-Mercer et al. 2011). Despite scientific studies measuring sediment loads on the Yukon River, the limited availability of long-term scientific data makes it difficult to establish what might be occurring (Dornblaser & Striegl 2009). Multiple interacting factors control erosion and deposition of sediments in rivers. The amount of sediment at any given point in a watershed is affected by two factors:

> 1) The amount of sediment eroded and transported to the stream from upland sources 2) The ability of a stream to carry the washed-in sediments and to re-work and transport bed and bank material. Streams can either be considered supply-limited or capacity-limited, depending on whether their ability to carry sediments exceeds the amount available or vice versa. (Gordon et al. 2004)

Further study of sediment regimes in the Yukon River is needed to understand the observed changes in sediments in Ruby and other locations in the YRB.

*Livelihood Impacts of Observed Changes in Hydrology*

Observations of hydrologic change are made possible by the detailed knowledge of water maintained by the people of Ruby. Alterations in hydrology have cascading impacts on the livelihood security of the people of Ruby. The above discussion of observations of hydrologic change reveals that climate change is impacting subsistence livelihoods in a number of ways including: access,

**Table 1 Examples of Observed Hydrologic Changes and their Impacts on Subsistence Harvesting in Ruby Village, AK**

| Impacts | Definition | Observations |
|---|---|---|
| **Access** | Hydrologic changes that alter access to important subsistence activities. Access primarily relates to the ability to travel on ice, snow or open water. | Reduced water levels in sloughs during the fall preventing entry by boat, especially during the fall when moose hunting takes place.<br>More sandbars are forming on the Yukon River, making travel to some sloughs more difficult.<br>Changing freeze-up and break-up dates for river ice temporarily can change time periods in which people have access to certain areas.<br>Changes in streamflow and sediments may be altering context specific conditions required to fish, i.e. Changes in eddies important for fishing salmon. |
| **Predictability** | Hydrologic changes that influence the ability to predict the weather including the timing and intensity of rain, snowfall and temperature and the cascading influence of these changes on the behavior of the Yukon River are crucial to subsistence livelihoods. | The weather these days is strange and it is harder to predict.<br>Increased variability of rain and snowfall.<br>Reduced ability to predict when river ice will either freeze or break-up.<br>Reduced predictability of streamflow on the Yukon River. |
| **Safety** | Hydrologic changes that reduce the safety of subsistence harvesters. These include travel conditions on the Yukon River and its tributaries, which are transportation corridors when they are frozen and during times of open water. | Increased number of open leads (unfrozen spots) on the river make travel on the river ice dangerous. |
| **Species Availability** | Hydrologic changes that impact the availability of subsistence species either by introducing new species to the area or reducing the availability of other species through altered migration. | Observed changes in salmon populations may be influenced by climate since streamflow and temperature may affect salmon populations as they are controlling factors in their lifecycles (Bryant 2009). |

predictability, safety and species availability.[7] Table 1 provides some illustrative examples of observations of hydrologic changes and their impacts on subsistence livelihoods. The influence of climatically induced hydrologic changes on subsistence livelihoods highlights the importance of this research project not only for furthering scientific knowledge of the impacts of climate change on water resources, but also for understanding the complex ways that social-ecological relations are being altered. Knowledge of biophysical processes and their impacts on subsistence livelihoods is essential to the formulation of adaptation and mitigation strategies.

***Conclusion and Recommendations***

The concept of *phronesis* (practical wisdom) allows us to conceptualize how indigenous knowledge and western science can be linked in the same process of knowledge generation as we seek to understand the impact of climate change on water resources. Indigenous knowledge exemplifies the process of *phronesis*, where knowledge generation cycles between context-dependent knowledge (*knowing how*) and context-independent knowledge (*knowing that*). In other words, indigenous knowledge is generated and continually refined through the practice of engaging in subsistence livelihoods. Scientific research follows a similar process. Furthermore, the concept of *phronesis* demonstrates how these two forms of knowledge can be linked in the same iterative process of action and reflection. This research represents and attempt to link indigenous knowledge and western science in the same process of knowledge generation. Community expert's observations of hydrologic change are compared and contrasted with findings from climate literature in order to improve

[7] Climate impact categories adapted from Berkes and Jolly (2001).

understandings of the impacts of climate change on water resources.

The case of Ruby Village indicates that there are hydrologic changes occurring in the YRB including alterations in temperature, precipitation, permafrost, streamflow and sediment and river ice regimes. While the research findings from this paper are based on one case study, many of our findings are comparable to indigenous knowledge studies conducted within the last five years in other locations in the YRB (Carey 2009; Herman-Mercer et al. 2011; McNeeley 2009). Many of the observed changes in water resources can be linked to complex processes that are not adequately explained by the corresponding climate literature. These observations demonstrate the value of indigenous knowledge to reveal new areas of inquiry related to climatically driven hydrologic change and highlights three possible areas for future investigation. First, findings from Ruby Village indicate that the timing of break-up has not shifted as much as it has in other rivers in the Arctic and Subarctic. However, changes in the timing and acoustic qualities of break-up compel further research into the impacts of climate on river ice. These changes in break-up on the Yukon River could indicate a change in ice morphology. There is also a possibility that more thermal break-up is occurring prior to mechanical break-up affecting both the timing and sound (Rundquist 2009). In depth studies of ice formation, morphology and break-up in the Yukon River are currently lacking and should be the focus of future studies. Second, observed changes in sediments and sandbars on the Yukon River are not explained due to a current lack of long-term data. Changes in sediments can indicate other major hydrologic and ecological change in the watershed and can have serious implications for the local ecology. Indigenous observations of changes in sediments in this and

other case studies indicate a need for further research.

Indigenous knowledge and western science are essential to understanding climate change and its impacts. This study indicates that indigenous knowledge can be invaluable to understanding hydrologic change. Indigenous knowledge can contribute to the scientific understanding of hydrologic change in at least three ways. First, indigenous knowledge can fill in the gap when there are little to no western scientific observations related to specific areas of hydrologic change. In Arctic and Subarctic watersheds, there is a paucity of long-term data in areas crucial to understanding the impacts of climate change on hydrology of these river systems. In the absence of scientific data on river ice break-up, freeze-up and ice thickness and river sediments, research findings from Ruby Village indicate that indigenous observations of change are essential to understanding the changes that are occurring in the YRB. Second, indigenous knowledge can open-up new areas of inquiry by contributing observations not previously considered by western scientific studies. For example, observed changes in the acoustic dimensions of river ice break-up or the importance of changes occurring in sediment regimes can contribute to the generation of new research questions that can be investigated using both indigenous and western science. Third, along with western methods of observation, indigenous knowledge can be used simultaneously in long-term monitoring projects.

Indigenous knowledge research is also valuable to indigenous communities. Indigenous knowledge is essential to the formulation of adaptation and mitigation strategies that address the impacts of climate change on indigenous communities and their livelihoods (Nyong et al. 2007). Hydrologic changes have cascading ecological

impacts that affect subsistence species and their habitat. Since indigenous peoples are among the most affected by climate change (Crate & Nuttall 2009; Adger et al. 2006), researchers have an ethical responsibility to structure research in such a manner that it can contribute to the formulation of strategies to mitigate or adapt to the impacts of climate change. A participatory research approach is essential to accomplishing this task because it provides a research framework aimed at addressing the power relations between the holders of indigenous and western scientific knowledge as it makes researchers accountable to the communities that they are working in. Furthermore, the successful formulation and implementation of responses to climate change depends on the participation of indigenous communities during all phases of research.

Future studies of hydrologic change can be improved in at least two ways. First, the present study is a limited one case study. Deeper understandings of hydrologic changes require a watershed scale perspective. Future studies should incorporate multiple case studies from various other locations within the same watershed, for example Yukon First Nation or Alaska Native communities from the headwaters to the mouth of the Yukon River where it drains into the Bering Sea. Second, this study is also limited by its reliance on social science methodologies alone. Future research should be conducted using multidisciplinary research teams that incorporate methodologies from the social and biophysical sciences in order to effectively identify and investigate observed hydrologic changes.

# CHAPTER 2
# THE POLITICS OF ADAPTATION:
# CLIMATE CHANGE VULNERABILITY SUBSISTENCE LIVELIHOODS IN THE KOYUKON ATHABASCAN VILLAGE OF RUBY, AK

## *Introduction*

Arctic and Subarctic regions of the world are experiencing some of the most extreme impacts of climate change (Nuttall et al. 2005). Although local impacts can vary widely (Ibid.), climate change poses substantial risks to indigenous peoples across the Arctic and Subarctic (ACIA 2005). Many of these risks are associated with subsistence livelihoods, which continue to have socio-cultural and ecological significance for indigenous peoples (Kassam 2009; Wheeler & Thornton 2005). While little research on the human dimensions of climate change existed a decade ago, there are now a large number of studies documenting the impacts of climate change on indigenous peoples of the Arctic and Subarctic (ACIA 2004; Herman-Mercer et al. 2010; Kassam 2009; Krupnik & Jolly 2002; Nichols et al. 2004; Reidlinger & Berkes 2001). These studies primarily examine climatic impacts from the perspective of vulnerability and adaptation to climate change.

## *Vulnerability and Adaptation to Climate Change*

While mitigation is of continuing importance to addressing the root causes of climate change, the slow pace of political negotiations to reduce greenhouse gas emissions and evidence suggesting that we are committed to a certain about of warming has motivated a shift in focus towards adaptation (Ford & Smit 2004). Adaptation to climate change is broadly defined as an "adjustment in natural or human

systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007, p.869). Adaptation is a process that occurs at multiple and interacting scales simultaneously (Adger et al. 2005). Furthermore, adaptation can be planned or spontaneous and depending on its timing, can be either anticipatory or reactive (IPCC 2007; Smit & Wandel 2006). This paper takes a community-based approach that defines adaptation as "a community-led process, based on communities' priorities, needs, knowledge, and capacities, which should empower people to plan for and cope with the impacts of climate change" (Reid et al. 2009, 13). Community-based approaches to adaptation suppose that there are many ways to respond to the impacts of climate change and local communities are the most qualified to determines their path to adaptation (Smit and Wandel 2006).

Recent scholarship on climate change has drawn on the theory of vulnerability to explain why some populations are more able to adapt than others (Adger & Kelly 1999; Agrawal & Perrin 2009; Ribot 1995). Vulnerability is defined as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of change and variation to which a system is exposed, its sensitivity and its adaptive capacity" (IPCC 2007, p.883). Other social and biophysical non-climatic drivers of change also contribute to vulnerability (Sullivan and Huntingford 2009) (Figure 12).

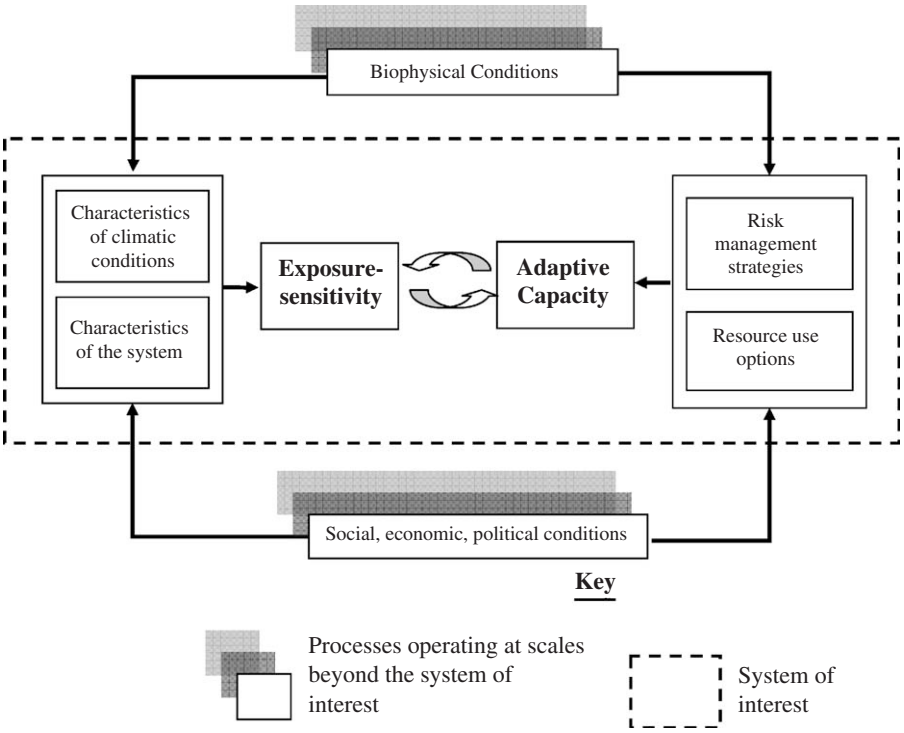


**Figure 12 Conceptual model of vulnerability. Illustrates components of vulnerability including social, economic and political and biophysical conditions acting on the system (Ford & Smit 2004, p.147).**

The study of vulnerability is rooted in three theoretical approaches (Eakin & Luers 2006). First, the risk-hazard approach to vulnerability comes from natural hazard literature (White 1973; Burton et al. 1993). The risk-hazard approach measures vulnerability as the difference between biophysical risk factors and potential loss (Eakin & Luers 2006). Second, a political-economy/political-ecology approach examines vulnerability resulting from social inequalities and conflict in societies, with more emphasis on power relations than traditional risk-hazard approaches (Eakin & Luers 2006). Such an approach emphasizes difference in vulnerability based on 'exposure units,' defined variously as class, ethnicity, etc. that are the basis for differential entitlements (Turner et al. 2003). Third, an ecological resilience approach

defines vulnerability in the context of stresses acting on coupled social and ecological systems where humans are constantly interacting with the biophysical environment (Eakin & Luers 2006). C.S. Holling (1973) defines resilience as the ability of a system to absorb change and disturbance without changing its structure or relations. Resilience is an important factor in determining the potential for societies to adapt to environmental changes because "the adaptive capacity of all levels of society is constrained by the resilience of their institutions and the natural systems on which they depend. The greater their resilience, the greater is their ability to absorb shocks and perturbations and to adapt to change" (Berkes et al. 2003, p.14). Resilience is understood as the converse of vulnerability and must be taken into account in order to avoid conceptualizing local communities as the passive victims of change (Kassam et al. 2011). Because the characteristics of particular systems differ, understanding resilience within those specific contexts is an important element of analysis in socio-cultural and ecological systems (Turner et al. 2003). Since, vulnerability is not only a function of environmental or biophysical variability, but also of socio-political and institutional factors (Adger et al. 2006; Agrawal & Perrin 2009), it has been noted that a coupled social-ecological approach should be applied (Adger 2006; Turner et al. 2003). In this way, the ecological resilience approach addresses the weaknesses of the first two approaches to vulnerability by incorporating both social and biophysical factors of vulnerability within a complex and multi-dimensional system. Most approaches to vulnerability represent some combination of the three approaches defined above (Eakin & Luers 2006).

The impacts of climate change on Arctic and Subarctic indigenous communities have primarily been studied from a vulnerability perspective (Chapin III et al. 2004; Ford 2007; Ford & Pearce 2010; Ford et al. 2006; Furgal & Seguin 2006; Kassam et al. 2011; McNeeley 2011). While the vulnerability approach to adaptation is useful in understanding the complex interconnection between social and ecological factors as outlined above, it can be strengthened by more explicit attention to the ethical dimensions of climate change adaptation (Adger et al. 2006). First, justice is a central to adaptation due to the reality that indigenous peoples are among the world's populations who have contributed the least to the causes of climate change and yet they are most affected by its impacts due to the close connection between their livelihoods and their local ecology (Crate and Nuttall 2009; Mearns and Norton 2010). Second, the study of vulnerability and adaptation has been critiqued for the failure to sufficiently acknowledge the influence of the broader political context on a human community's capacity to respond to change (Cameron 2011). Indigenous peoples' experience of responding to the dramatic impacts of a history of colonialism has significant bearing on the present political context of adaptation. Given indigenous peoples' documented ability to adapt to ecological change, it has been suggested that some of the largest barriers to climate change adaptation will be political rather than ecological (Wenzel 2009). Therefore, understanding the political context within which indigenous peoples are responding to the impacts of climate change adds further complexity to our analysis of justice in adaptation.

The study introduced in this paper focuses on the political context for adaptation in Ruby Village, AK by examining the influence of historical social

changes on subsistence livelihoods and the bearing these changes have on their present experience of adaptation to climate change. Subsistence livelihoods are examined through the lens of human ecology. Karim-Aly Kassam's reconceptualization of human ecology is defined as "the relationships between people and their environment, which includes relations between humans and human relations with other animals, plants, and their habitats" (Kassam 2009, p.65). Human ecology collapses the false dichotomy between nature and culture and demonstrates the connection between biological and cultural diversity (Kassam 2009). During interviews, community experts shared knowledge of 14 key subsistence livelihood practices and discussed how subsistence has changed since the 1950s.

***Context***

Ruby Village is situated in the middle river region of the Yukon River (64°44'22.00"N, -155°29'13.00"W). While the land and water surrounding Ruby Village has been part of the traditional territory of the Koyukon Athabascans for millennia, the settlement itself was founded as a supply point for gold prospectors during the mining booms of 1906 and 1910 (Larson 2006). After WWII, most miners had moved away and Ruby became mainly a native Village. The current population of Ruby is 166 persons, living in 62 households. Approximately 87 percent of the residents of Ruby are Alaska Native (U.S. Census 2010) (Figure 13).

The village is located on the south bank of the Yukon River between the Villages of Tanana and Galena, adjacent to the Nowitna National Wildlife Refuge in the Kilbuk-Kuskokwim Mountains. This region, in the interior of Alaska, has plentiful bogs, streams, lakes and sloughs, open spruce forests and shrubs and provides habitat

for a rich variety of fish and wildlife including salmon, moose, diverse species of

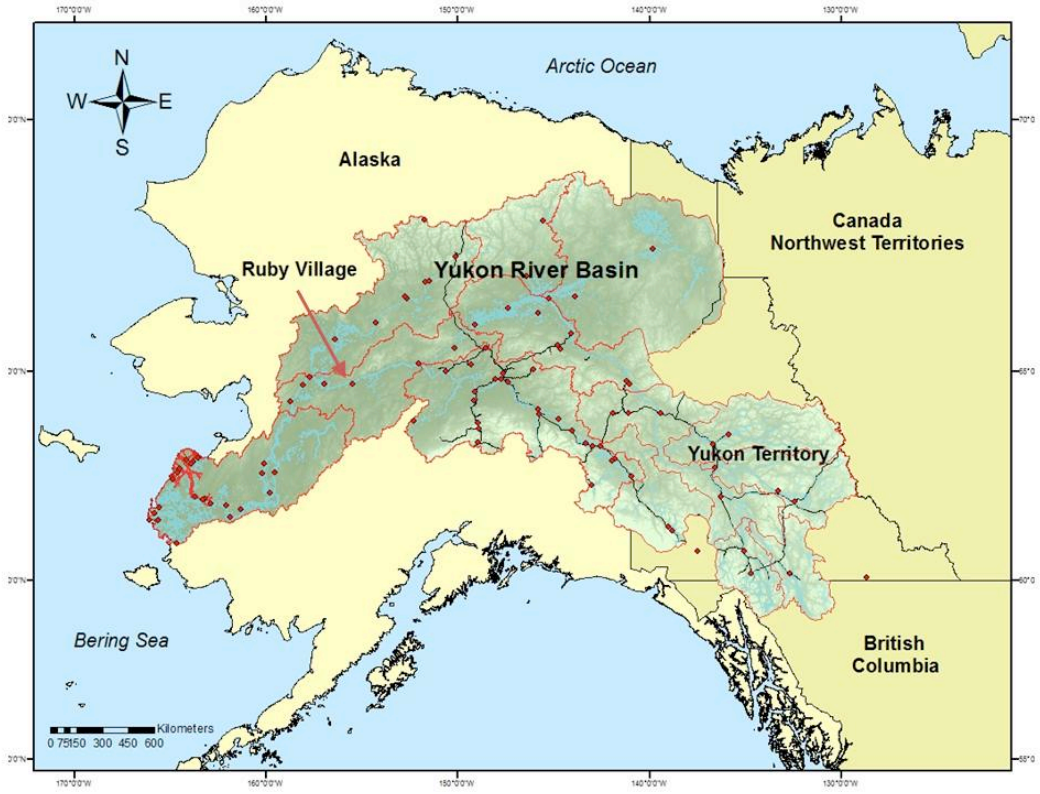


**Figure 13 Location of Ruby Village in the Yukon River Basin**

migratory waterfowl, bears, wolves, beaver and other small game (YRITWC 2002).

The people of Ruby rely on their local ecology to maintain subsistence livelihoods. Rural areas of Alaska depend on wild foods to a greater extent than urban areas (Wolfe 2000 cited in McNeeley 2011). Wild foods provide approximately 57 percent of the total calories and 396 percent of required protein in rural Alaska, whereas wild foods provide 2 percent of the calories and 15 percent of the protein needs in urban areas such as Fairbanks and Anchorage (Ibid.). The location of Ruby Village off the Alaska road system means that it is difficult and expensive to access other sources of food, which have to either be flown in or shipped to the village on the Yukon River barge system. For the people of Ruby subsistence is not only viewed as

a means to meet their basic nutritional needs, but also represents a way to maintain their traditional 'way of life' (Wheeler & Thornton 2005).

The climate of the interior of Alaska is characterized by natural variability, including extremes in annual temperatures and changes associated the Pacific Decadal Oscillation (PDO), which causes decadal shifts in climate averages (Salinger 2005). Furthermore, populations of subsistence species are known to go through dramatic fluctuations (Nelson 1986). Local subsistence livelihoods are adapted to the natural variability of the climate and ecology of the interior of Alaska (Nelson 1986; VanStone 1974). Specifically, subsistence livelihoods are characterized by a high level of flexibility that allow for shifts in the timing, intensity and location of harvesting depending on climatic and ecological factors that vary from year to year (Ibid.).

However, climate change is projected to result in climatic extremes that have not previously been experienced (ACIA 2004; IPCC 2007). These changes are already being observed. For example, mean temperature increases indicate that Arctic regions are disproportionately experiencing the effects of climate change (ACIA 2005; Hansen et al. 2006). Climate data from the interior of Alaska indicates some of the most marked warming statewide over the last six decades (ACRC and GI, UAF 2010). Despite adaptation to climatic variability, the unprecedented change associated with climate change has the potential to challenge the limits to which subsistence livelihood practices can be adapted. However, this paper is primarily concerned with the role that adaptation to past social changes have played in making the people of Ruby more or less vulnerable to the present impacts of climate change on subsistence livelihoods.

### *Methodologies*

Participatory Action Research (PAR) is an iterative approach to research used to generate knowledge through cycles of action and reflection (Greenwood and Levin 2008). Furthermore, PAR is a fundamentally ethical research philosophy that informs research methods and design in order that science can serve as the basis for social change (Greenwood and Levin 2008). Community collaboration in all aspects of research design and implementation is vital to PAR and contributes to the goal of affecting social change (Kassam 2009). Participatory approaches are especially well suited to the study of indigenous knowledge because they integrate reciprocity, which is integral to reducing the risk that research will reproduce colonial relationships between the researcher and research participant. Moreover, the attributes of indigenous knowledge, such as context specificity and complex connectivity to socio-cultural and ecological systems make participation a necessity (Kassam 2009).

This research project strives towards the ideal of PAR. The study can be characterized as participatory in the sense that it was designed and conducted in partnership with the Yukon River Inter-Tribal Watershed Council (YRITWC), whose goal is to meet the needs of the seventy indigenous governments in the Yukon River Basin they serve. Furthermore, the YRITWC facilitated a research partnership with the Ruby Tribal Council (RTC) and the project was modified to fit the context of Ruby

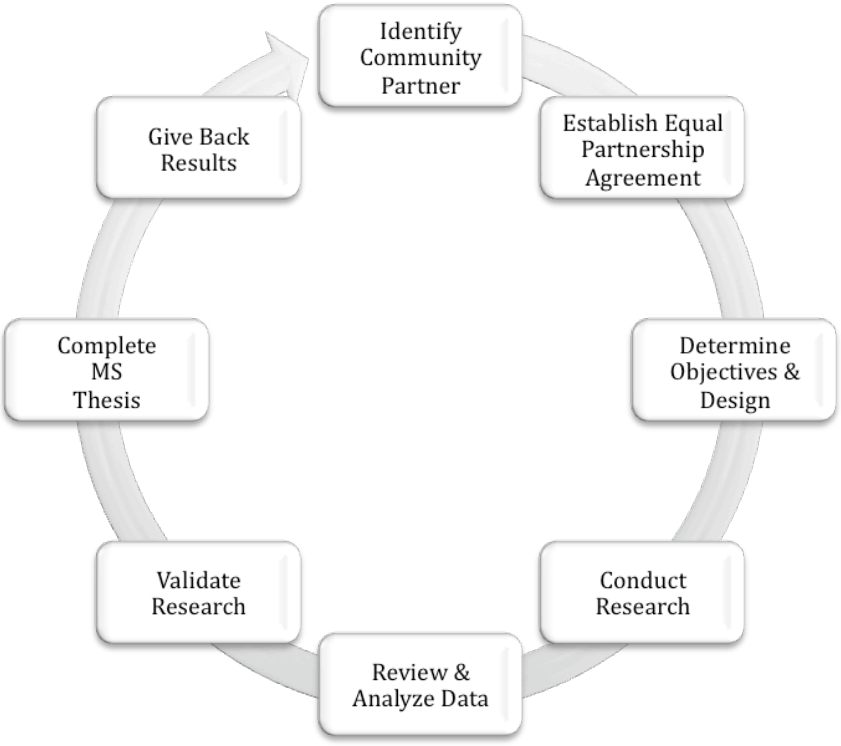


**Figure 14 Participatory Research Design depicts the stages of the research process carried out in partnership with the Yukon River Inter-Tribal Watershed Council and Ruby Tribal Council**

Village. All research data and outputs were validated by and shared with the RTC and the YRITWC (Figure 14). Working directly with community members to determine research objectives and design, rather than just the YRITWC, will strengthen future attempts at participatory research.

Research was conducted during two field seasons. The first of these field seasons took place between June and October 2010 and the second in July and August 2011 (Figure 15). During this time, semi-structured interviews were conducted with 20


**Figure 15 Conveys the iterative research process followed when conducting research in Ruby Village. Each community expert was visited a minimum of three times over the course of five research trips to Ruby Village.**

community experts, including Elders, subsistence harvesters and tribal administrators.[8] This included eight women and twelve men whose ages ranged from 49 to 92 (Appendix A). Interview participants were recruited using a snowball method where contacts at the Ruby Tribal Council were asked to make a list of the community experts who could contribute to the research (Patton 2002). Community experts were added to the initial list when referred by other interview participants.

Interviews were conducted using an iterative process. A minimum of three

[8] Community experts were selected based on recommendations from other members of the community. Each of the community experts was heavily involved in subsistence practices and had lived in Ruby for an extended period of time, if not their whole life.

meetings was held with each interview participant.[9] During an initial interview, participants were asked to describe their subsistence livelihoods and observations of social and ecological change. Specific follow-up questions were asked to clarify responses. Interviews were documented using written field notes rather than audio recordings. The author wrote a narrative essay based on interview field notes.

Seasonal rounds depicting the timing of fourteen subsistence livelihood activities were created based on interview data. These calendars include both the twelve-month Gregorian calendar and selected months from the Koyukon traditional lunar calendar.[10] Seasonal rounds were produced to represent past and present subsistence practices. A pre-1950s seasonal round was created based on input from several Elders including, Clara Honea, Lorraine Honea, Billy McCarty and Martha Wright, who were actively involved in subsistence during this era. Of the twenty community experts interviewed, fifteen participated opted to make seasonal rounds representing present subsistence practices. Three married couples created a seasonal round to show their combined harvesting. A total of twelve seasonal rounds resulted from this research.

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[9] All community experts were visited a minimum of three times. However, at the request of the community experts, additional visits were paid and further information was added to interview narratives as needed.

[10] Community experts reviewed the 16-month Koyukon traditional lunar calendar. Although most of the months from the calendar recorded by Jules Jetté were recognized as they corresponded to phenological changes, there were a number of names that were unfamiliar or did not make sense to interview participants. These terms included: 'month of the eagle' (February), 'month of the hawk' (March) and 'month which has no name' (early December). It was not clear why the 'month of the hawk' and 'month of the eagle' represented February and March. Elder Billy McCarty suggested that these months be replaced with something indicating that the majority of beaver trapping takes place in February and March. Although the months of the calendar generally follow phenological cues these sometimes arrive out of order. For example, the order of salmon runs represents the peak of those runs, but individual salmon often come at varying times.

Typed versions of interview narratives were validated during a second interview. Interview narratives were read out loud to the interview participant. Participants were also presented with images of three seasonal rounds for validation including those depicting subsistence practices prior to the 1950s, their individual harvesting and the combined harvesting for all participants. At the time of validation, changes were then made to interview narratives and seasonal rounds to correct data or to add other important information that was left out during the initial interview. During a third visit, final printed versions of final of interview narratives and seasonal rounds were given to each participant for their records.

Human ecological mapping was conducted as part of interviews. Interview participants were asked to place icons representing key species, livelihood activities and drinking water sources on a 1:250,000 scale topographic map encompassing the traditional territory of the people of Ruby Village.[11] This map was then digitized using ArcGIS. A printed version of the digitized map was then presented to interview participants during follow-up interviews where additional icons and place names were added and feedback regarding the layout was gathered.

Interview narratives were coded for observations of change using Text Analysis Mark-up System (TAMS) Analyzer, a qualitative data analysis tool. The interpretation of this research was then shared with the community for validation during a public presentation in Ruby Village in July 2011. The presentation included sharing printed versions both of the human ecological map and seasonal rounds.

[11] Icons were adapted from previous human ecological mapping projects conducted in Wainwright, Alaska and Hay River, Northwest Territories (Kassam & Soaring Eagle Friendship Centre 2001; Kassam & Wainwright Traditional Council 2001).

Community experts consented to having their names used in this research. Their names are used as a form of citation and to recognize the contribution their knowledge has made to this research.

***Results and Discussions***

Adaptation is a pertinent topic for the people of Ruby who are already experiencing the impacts of climate change. Research findings indicate that the study of adaptation should not only seek to understand the immediate impacts of climate change on subsistence livelihoods, but must also consider the ways that the political and historical context in which harvesting takes places influences a community's ability to respond to these changes. The people of Ruby and their subsistence livelihoods have undergone dramatic social change since the 1950s that can affect their capacity to adapt to the impacts of climate change in the present.[12] In the analysis that follows, I briefly review the observed impacts of climate change on the subsistence livelihoods of the people of Ruby. I will then explore how the people of Ruby responded to past social changes and examine the implications of these adaptations for current for responses to climate change.

*Observed Impacts of Climatic Change on Subsistence Livelihoods*

Community experts are observing a wide variety of climatic changes in the area around Ruby Village (Table 2). These impacts can be divided into four categories: access, predictability, safety and species availability

[12] Significant social change certainly occurred prior to this era, for example, the gold booms of 1906 and 1910 resulted in a massive population influx into the area-surrounding Ruby Village. At the height of the gold boom the population is estimated to have been as high as 10,000 (Larson 2006). However, the 1950s are used as a baseline in this study because the pertinent changes in subsistence livelihoods identified by community experts all occurred after this date.

**Table 2 Examples of Observed Environmental Changes and Their Impacts on Subsistence Harvesting in Ruby Village, AK**

| Impacts | Definition | Observations |
|---|---|---|
| **Predictability** | Climate impacts that reduce the ability to predict weather including rain, snowfall and temperature to detriment of a harvester's ability to plan and carry out subsistence livelihood activities. | The weather these days is strange and it is harder to predict the weather.<br>Increased variability of rain and snowfall.<br>Reduced ability to predict when river ice will freeze or break-up.<br>Reduced predictability of streamflow on the Yukon River. |
| **Access** | Climate impacts reducing or preventing access to a particular area for subsistence harvesting. Access can be influenced by change in ice, snow or open water crucial for transportation. | Sandbars forming at the mouths of sloughs reduce access by boat.<br>Reduced water levels in sloughs during the fall preventing entry by boat and therefore access to key hunting areas and subsistence materials such as lowland birch.<br>Changing freeze-up and break-up dates for river ice temporarily can change time periods in which people have access to certain areas.<br>Changes in streamflow and sediments may be altering context specific conditions required to fish, i.e. changes in eddies important for fishing salmon. |
| **Safety** | Climate impacts reducing the safety of subsistence harvesters, largely in the course of travel safely on the Yukon River and its tributaries. Safety is closely linked to predictability. | Increased number of open leads (unfrozen spots) on the river make travel over frozen rivers and sloughs dangerous.<br>Water levels have been higher than normal on the Yukon River during the summer making travel and fishing on the river more dangerous at times.<br>Increased spoilage of meat due to higher fall temperatures. |
| **Species Availability** | Climate impacts reducing on the availably of subsistence species either through the introducing of new species to the area or reduction in the temporal or spatial availability of other species through altered migration or other factors. | Observed delay in moose rut, likely caused by increased temperature.<br>New birds have been observed.<br>Observed changes in salmon populations could be influenced by climate since streamflow and temperature may affect salmon populations as they are controlling factors in their lifecycles (Bryant 2009). |

(Berkes and Jolly 2001). While it is not the purpose of this paper to review these observations in detail, documenting the impacts of climate change is essential to the analysis of vulnerability and adaptation to change in Ruby Village. The following sections describe subsistence livelihoods prior to the 1950s and responses to the dramatic social changes that have occurred in recent decades in order to gain insight into the present vulnerability of subsistence livelihoods to climate change.

*Subsistence Prior to the 1950s*

A seasonal round representing subsistence practices prior to the 1950s was created based on interviews with several Elders including Lorraine Honea, Clara Honea, Billy McCarty and Martha Wright (Figure 16). Seasonal rounds depict the timing of 14 subsistence practices prior to the 1950s and in the present (For a detailed description of these practices see Appendix C). Before the 1950s, the people of Ruby followed a seasonal pattern of migration, moving three to four times a year. Elders from Ruby Village, including Martha Wright and Lorraine Honea, referred to this annual seasonal movement as the 'cycle of life'. They would spend the winter months hunting and trapping up the 'Novi' River (Nowitna River) and the summer months on the Yukon River, in the Village of Kokrines or at fish camp. Each fall, families would travel up the 'Novi' before freeze-up. They generally stayed in trapping camp for the rest of the winter with the exception of short trips back to the village around Christmas and New Years and in the early spring to trade their furs and collect the supplies that would last the rest of the winter. Once spring break-up occurred, usually in late April or May, they would all leave their individual camps and meet at the mouth of the 'Novi' River. While they waited for everyone to arrive safely, they would fish and

hunt for moose. When everyone had arrived, they would tether their boats together and float down the Yukon River to Kokrines Village. A potlatch would be held in the village to celebrate the fact that everyone was back together again. In late May and early June, spring camp was practiced, where they would fish for whitefish, pike, burbot, sheefish and other fish until the salmon arrived. In mid-June they would go to fish camp, where they would fish for salmon. Fish camp would continue all summer until the end of August or early September. The whole cycle would then begin again as preparations took place to travel up the 'Novi' before freeze-up. The seasonal round for subsistence prior to the 1950s depicts the timing of harvesting during this era.

*Social Change and Subsistence Livelihoods*

Subsistence livelihoods have changed in a number of ways since the 1950s. The current seasonal round for Ruby Village depicts the timing of present harvesting by the people of Ruby (Figure 17). Human ecological mapping illustrates present land use by the people of Ruby (Figure 18).[13] Although the social changes the people of Ruby have experienced during this time are too numerous to name, three major changes that have influenced subsistence livelihoods: sedentization; intensified contact with the market economy; and the creation and enforcement of fish and wildlife regulations pertaining to subsistence harvesting.

In the 1950s, the people of Ruby stopped spending the winters up the 'Novi' and began to settle permanently. Sedentization, or settlement in a central village location rather than following a seasonal movement on the land, occurred as the result

[13] Human ecological mapping for past land use was not conducted. Interviews reveal that present land use is not as extensive as it used to be. However, the people of Ruby continue conduct subsistence livelihood activities within the majority of their traditional territory.

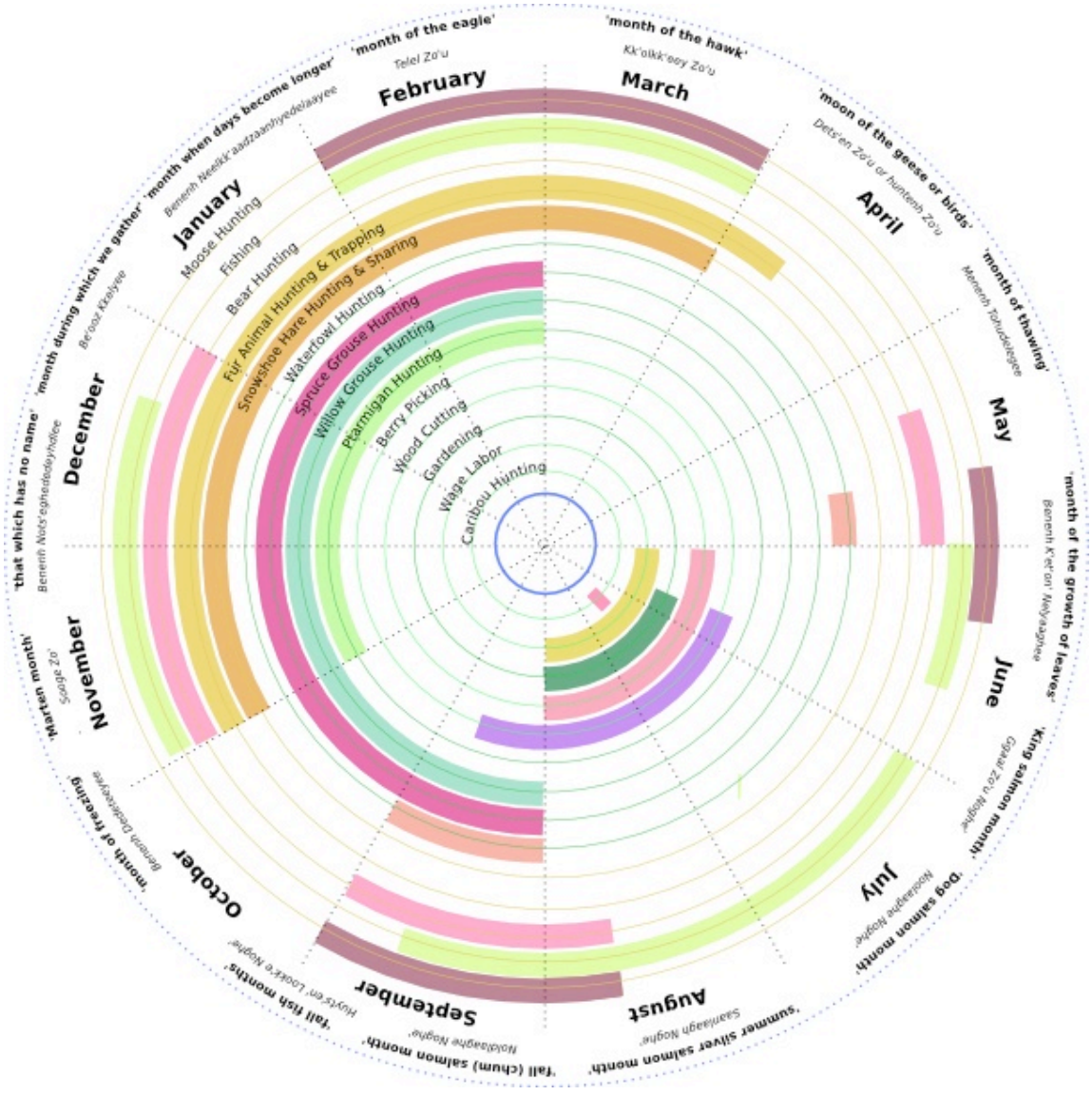


**Figure 16 Seasonal round of subsistence practices prior to 1950s was compiled based on knowledge contributed by Elders who were active in subsistence during this previous era.**


**Figure 17 Seasonal round of present harvesting practices combines livelihood activities for all community experts. The seasonal round shows the convergence and diversity in the timing of present subsistence practices in the community of Ruby.**

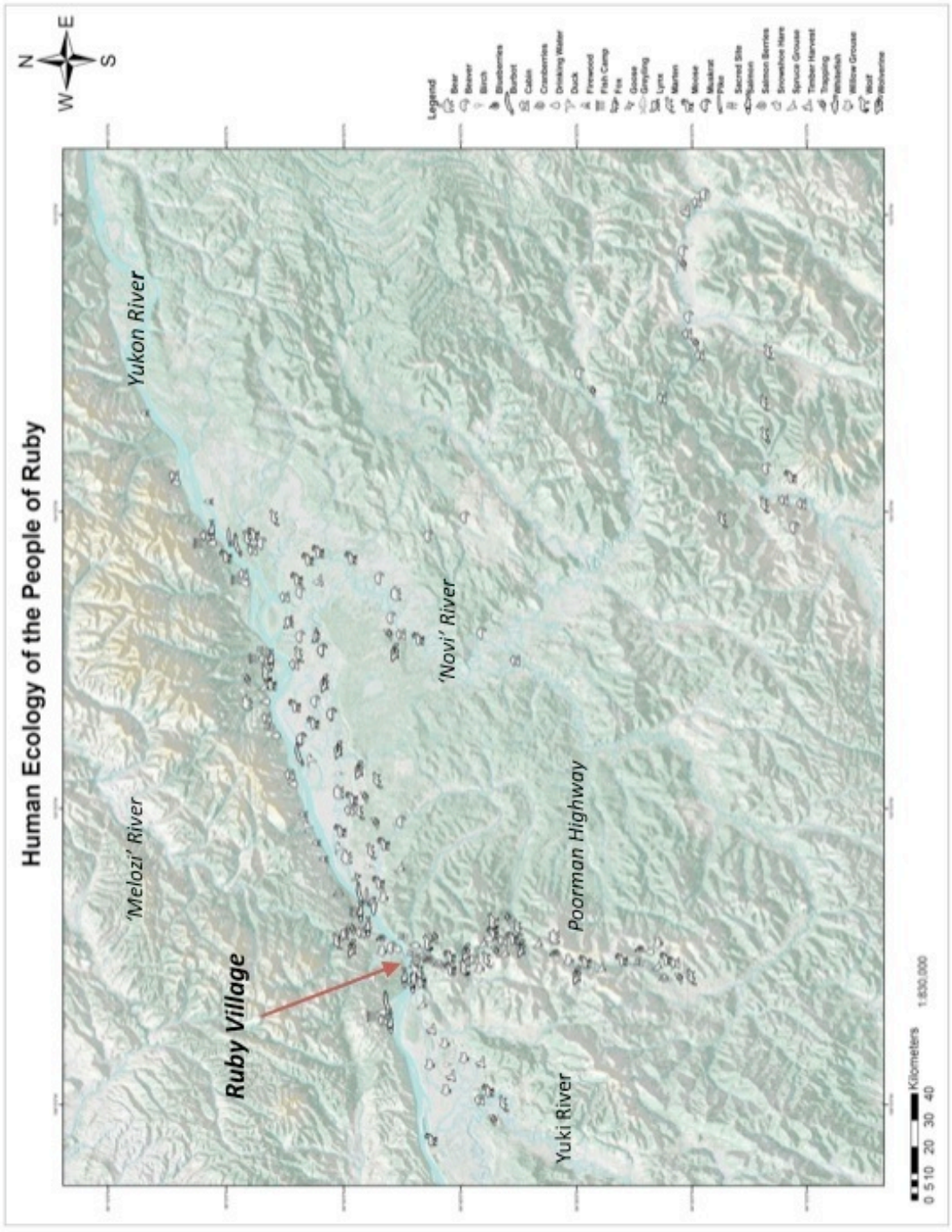


**Figure 18 Human ecological map of the people of Ruby Village. Illustrates present use of land and water. Although human ecological mapping for past land use was not conducted, interviews reveal that although present land use is not as extensive as it used to be, people still engage in subsistence livelihood activities through the majority of their traditional territory.**

of a number of influences including increased pressures to enroll children in schools. Once people were required to put their children in school they could no longer spend the whole winter in hunting and trapping camps as they used to. The effects of mandatory education on traditional seasonal migration have also been noted among other Alaska Native peoples (Dombrowski 2001; Kawagley 1999). People began to settle more permanently in the village of Kokrines and the majority of these residents moved to Ruby when the Kokrines' school was closed. Elder Lorraine Honea stated that she and her husband John Honea had trapped as far away as Lake Minchumina, near Denali National Park and Preserve (more than 200 miles away from the Ruby Village). After enrolling their daughter at the school in Ruby, they stopped travelling all the way to the 'Novi' River, hunting and trapping on the Yuki River instead. Although sedentization did not take place as the consequence of the same overt government policies promoting settlement and relocation that have been seen in the Canadian Arctic and Subarctic (Tester & Kulchyski 1994), mandatory education laws can be understood as an indirect, but nevertheless coercive means of encouraging people to settle.

Increased contact with the market economy was another major change that occurred after the 1950s. Following assimilationist theories of cultural change, it was predicted that indigenous cultures would be "'lost' through assimilation to expanding Euro-American cultures" (Erickson & Murphy 1998, p.74). Instead, cash and technologies such as snowmobiles have been actively integrated into subsistence economies, which continue to be an important way of life. The hybridization of traditional and market economies, where cash resources become an important input

into subsistence activities has been referred to elsewhere as the creation of a 'mixed economy' (Wenzel et al. 2000).

The introduction of new technologies was facilitated by contact with the market economy and has had lasting impacts on subsistence. Snowmobiles were introduced to Ruby Village in the late in the 1950s or early 1960s. The integration of new technologies, such as snowmobiles, is seen as an adaptive response to sedentization by indigenous peoples (Wenzel 1991, pp.164–166). While subsistence harvesters began to live in a central village location, snowmobiles allowed people to maintain a modified seasonal round in spite of the social disruptions that accompanied the increased distance from traditional hunting and trapping sites (Wenzel 1991). Although Elders such as Lorraine Honea and her late husband John Honea used dogs as their main method of transportation throughout their lives, travel over land in the winter is now done almost exclusively by snowmobile.

The use of snowmobiles also had some negative consequences. These and other new technologies created a dependency on cash and fossil fuels in order to maintain subsistence livelihoods. Emmitt and Edna Peters noted this dependency on fossil fuels:

> Gas for hunting is also expensive. Some people say that it is almost too expensive to hunt. You have to have gas to hunt. The price of gas in Ruby is currently about $4.80 a gallon. In Galena, it is almost a dollar more than Ruby. So, subsistence becomes difficult, unless you are going up the river in a canoe.

Reliance on fossil fuels makes subsistence harvesters vulnerable to fluctuations in the market economy. The impending global fuel crisis highlights problems associated with dependency on fossil fuels that are likely to intensify in the future.

Harvesting regulations have also had a major impact on subsistence livelihoods. A comparison of seasonal activities prior to the 1950s and in the present demonstrates that hunting and fishing regulations reduced the flexibility that had previously characterized all aspects of subsistence, including the timing, location and intensity of peoples' practices. Junior Gurtler stated, "before if you wanted a moose you would just hunt it." Karen and Junior Gurtler commented on the impacts that the enforcement of regulations have had on subsistence livelihoods:

> [The Alaska Department of] Fish and Game is giving out a lot of tickets. It didn't used to be like that. You used to be able to get what you needed and Fish and Game would only come every five years or so. Now they are coming all the time. Now you have to have a license.

Regulations have seriously impacted subsistence by limiting practices to the open season and to a designated bag limit or the number permitted to be harvested. The failure to follow these regulations results in serious penalties.

Since the 1950s, subsistence regulations have undergone significant change. Alaska Statehood in 1959 brought about major changes in subsistence regulations. The Statehood Act (1958) refused to acknowledge the rights of Alaska Natives to land or property held in trust for them and gave the state the right to select more than 103 million acres of lands they considered "vacant, unappropriated, and unreserved…" (US Public Law 85-508 1958). Although aboriginal title to these lands was never extinguished, the state treated the traditional territories Alaska Natives as part of the public domain. Consequently, the push to regulate subsistence began in 1958. Alaska Natives actively resisted these regulations by pushing for the recognition of Native subsistence rights (Berger & Alaska Native Review Commission 1985).

In 1971, motivated by a growing interest in developing natural resource extraction, such as the discovery of oil at Prudhoe Bay (1968), the Alaska Native Claims Settlement Act (ANCSA) was passed to extinguish native rights to the land and its resources. ANCSA resulted in the creation of 13 regional corporations and the allocation of 44 million acres (10 percent of the total land) and $962.5 million dollars in compensation for relinquished lands (about three dollars per acre). At the same time 197 million acres of land were reserved for the federal government (60 percent of the total land), and the State of Alaska was granted the remaining 124 million acres (30 percent of the state) (Berger & Alaska Native Review Commission 1985).

ANSCA also included a vague promise that native subsistence rights would be protected. This protection was not realized until 1980 with the passage of the Alaska National Interest Lands Conservation Act (ANILCA). ANILCA applies exclusively to federal lands. Title VIII of ANILCA creates a rural subsistence priority. Subsistence rights to wild resources are promoted over all other uses, including recreational and commercial uses in times of shortage. Conservation is the only goal that takes priority over rural subsistence (US Public Law 96-487 1980). The subsistence rights guaranteed by ANILCA are not exclusive to Alaska Natives since they are granted on the basis of rural residency. However, ANILCA acknowledges the importance of subsistence rights for native cultural existence, allowing for hunting for 'customary and traditional uses' such as hunting a moose for a community potlatch (Congress 1980; Berger & Alaska Native Review Commission 1985). In contrast, the State of Alaska guarantees a subsistence priority for all Alaska residents (Alaska. 1956). Subsistence rights in Alaska, as defined by the state and federal government, are

viewed as problematic by many native people, for whom competition for scarce resources poses a threat not only to their food security, but to their way of life (Thornton 2001; Wheeler and Thornton 2005). It is for this reason that subsistence rights continue to be one of the most hotly debated issues in Alaska (Wheeler & Thornton 2005).

Subsistence is regulated by both state and federal agencies. Changes in subsistence regulations are determined by both the federal subsistence board and State Board of Game (BOG) and implemented by the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game respectively (Carey 2009). The Alaska Department of Fish and Game (ADF&G) manages the hunt on all state and private lands including native allotments and lands held by native corporations. U.S. Fish & Wildlife regulates hunting on all federal lands including as Nowitna National Wildlife Refuge (the 'Novi') part of the traditional territory of the people of Ruby. The people of Ruby hunt in the Middle Yukon Region, which consists of a patchwork of native corporation selected land, native allotments, state and federal lands (Unit 21).

Subsistence Livelihoods, Vulnerability and Adaptation to Climate Change

Climate change is having significant impacts on subsistence livelihoods. The people of Ruby are shifting some of their harvesting practices in response to these changes. Responses to the impacts of climatic changes on subsistence livelihoods indicate that social vulnerabilities created by adaptation to past social change have bearing on the current ability to adapt to change (Table 3).

The potential for social vulnerabilities to constrain adaptation to ecological change is illustrated by several examples. First, adaptation to the impacts of climate

**Table 3 Summary of Adaptations to Past Social Change and Present Vulnerabilities**

| Social Change | Adaptation/Coping Mechanism | Impact | Present Vulnerability | Climate Impact |
|---|---|---|---|---|
| **Sedentization or settlement in a central village location** | Use of snowmobiles to maintain seasonal rounds | Dependence on gas and cash resources | Vulnerability to fluctuations in market economy | Reduced access and predictability in subsistence livelihoods can mean that people need to travel further or longer to obtain their harvest. Their capacity to do this is limited by access to cash and other resources. |
| **Increased presence of the market economy** | Development of a 'mixed economy' | Dependence on cash resources economy | | |
| **Creation & enforcement of subsistence harvesting regulations** | Changes in timing, intensity and location of harvesting | Reduced flexibility of (control over) subsistence harvesting (intensity, timing and location) | Restricted ability to adapt subsistence harvesting to ecological change | Climate impacts leading to reduced predictability and access highlight challenges associated with the loss of flexibility |

change will be influenced by a dependency on cash resources and fossil fuels. The development of a mixed economy and the use of new technologies represent adaptive responses to the social changes by people of Ruby. While these adaptations allowed the people of Ruby to maintain subsistence livelihoods in spite of dramatic social change, they have resulted in a dependency on cash resources and fossil fuels that make the people of Ruby vulnerable to fluctuations in the market economy. The above case study indicates that dependency on cash and fossil fuels have important implications for subsistence livelihoods. Climate change adds complexity to this

scenario. Climatic changes requiring the people of Ruby to hunt for longer or travel further away in order to meet their subsistence needs will be influenced by these dependencies because the ability to respond to ecological changes is limited by the availability of resources. For example, reduced fall water levels in sloughs can be a barrier to accessing important hunting grounds. The inability to access certain sloughs by boat can mean that hunters need to travel further, using more gas, to hunt for moose.

Second, adaptation to climate change is constrained by the people of Ruby's loss of flexibility and control over subsistence harvesting due to the creation and enforcement of fish and wildlife regulations. The imposition of regulations removed local control over decision-making about subsistence harvesting including choice regarding the timing,[14] intensity and locations where harvest is permitted. Climate change is impacting subsistence species and their habitat. For example, the people of Ruby are already observing and responding to the impacts of climate change on moose hunting.[15] Increasing temperatures are believed to be a factor in observed a shift in the timing of the moose rut to later in the fall. George Albert noted,

[14] Interview narratives and pre-1950s seasonal rounds indicate that while the people of Ruby were previously able to hunt moose at any time of year, they would primarily hunt moose during the fall (August and September), as the do now, and in the spring (February and March). Cow moose were primarily hunted during this time because they are typically in better shape than bull moose, with more fat, after with winter. Moose would also be hunted after break-up if there were no other food sources available.

[15] Moose hunting is one of the most significant subsistence livelihood activities for the people of Ruby. Approximately 88 percent of the people of Ruby use moose meat. 64 percent of households participated in hunting and 40 percent successfully hunted a moose. Of those who hunted a moose 60 percent reported sharing moose meat (Brown et al. 2004). Moose hunting is not only important as a means of meeting the nutritional needs of the people of Ruby, it is also a culturally important activity and considered part of a way of life.

> …except for this year [2010], it has been too warm. It has been hard for the moose because they don't start moving around until really late. One odd thing I noticed about moose is that last year, they got a bull moose on the 16th of September and he was with two cows but wasn't even in rut either. He didn't smell or anything. Somebody else got a moose that late also and it was not in rut.

Several other interview participants made similar observations regarding a delay in the rutting season, which they believed to be triggered by increasing temperatures. Fall breeding dates are determined by photoperiod [length of daylight] (Schwartz 1998) and temperature, where cool temperatures cause bulls start to move around in search of cows (Bubenik 1997). The exact temperature that triggers bull movements is not known, however other Koyukon hunters in the interior of Alaska have similarly observed that increasing temperature is contributing to a delayed bull movement (McNeeley 2009; 2011).

The ability of the people of Ruby and other Alaska Native hunters to shift the timing of their harvest in response to the delayed rut is limited by state and federal subsistence hunting regulations.[16] Regulations are implemented in response to perceived declines in moose populations. Threats to moose populations identified by conservation biologists (Stout 2008) and the people of Ruby include predation by wolves, weather and overhunting, largely by non-local hunters. The objective of these regulations is twofold: 1) to maintain and enhance moose populations and their habitat

[16] The open season for moose hunting occurs during the fall. In the area around Ruby, ADF&G regulates an open season from Aug. 22–Aug. 31 and September 5th to 25th (on state and private lands including lands held by native corporations) and U.S. Fish & Wildlife regulates a hunt from September 26th to October 1st (on federal lands) (AFWS 2010). Moose hunting is no longer permitted at any other time of year, with the exception of taking a moose for community potlatches or other traditional purposes. The harvest is limited to one moose per person. People are only allowed to hunt bulls with antlers. Hunting cow moose in the area near Ruby is prohibited. Hunting regulations, seasons, bag limits and means of hunting are determined by both the state and federal boards of game and implemented by their respective agency (Carey 2009).

and; 2) to provide sustained opportunities for moose hunting for subsistence and sport hunters (Stout 2008). As described above, federal regulations give subsistence priority to rural residents while state regulations grant these rights to all Alaska residents.

The observed shift in timing of the moose rut has prompted negotiations to alter the timing of the regulated fall subsistence hunt. The people of Ruby and other Alaska Native Villages in the Koyukon region of Alaska have negotiated with both state and federal agencies in an attempt to lengthen or shift the timing of subsistence hunting later in the fall season (McNeeley 2011). In 2008 and 2009, they had especially poor moose seasons. According to Ed Sarten, Ruby Tribal Fish & Wildlife Coordinator, The Ruby Tribal Council bargained with state and federal agencies to change the hunting season in response to the need to harvest more moose. The impacts of temperature on the timing of rut were considered during the process. While U.S. Fish and Wildlife was responsive to the possibility that climate change may be a factor affecting moose harvest for the people of Ruby, the ADF&G took the position that climate does not affect the timing of the rut and hunting should not take place during the peak breeding dates, which, they assert, occur between the September 25$^{th}$ and October 5$^{th}$ (Van Ballenberghe & Miquelle 1993). Notably, this position is based on studies of the median copulation dates of moose conducted between 1982 and 1987, making the data nearly three decades old (Ibid.). Consequently, U.S. Fish and Wildlife extended the season, on the Nowitna Wildlife Reserve by one week, September 25$^{th}$ and October 1$^{st}$. The ADF & G extended the hunt by an additional five days at the end of August.

The case of moose hunting and climate change shows that the people of Ruby have some influence over the process through direct negotiation with these agencies; it also demonstrates the potential for fish and wildlife regulations to increase vulnerability by constraining their ability to respond to the impacts of climatic change on subsistence species and their habitat. Regarding this situation, Shannon McNeeley states, "Alaskan communities are impacted by a regulatory decision-making process that, to date, can't effectively respond to slow-onset climate change that impacts moose behavior and moose harvest success thereby threatening food security and community well-being" (McNeeley 2011, p.2). While the objectives of fish and wildlife regulations to conserve fish and wildlife populations are not in dispute, the manner in which indigenous communities, such as Ruby Village are involved in the decision-making process regarding subsistence livelihoods is problematic. This case study indicates that current institutional arrangements have the capacity to increase vulnerability to ecological change by reducing local control over harvesting decisions.

*Implications*

Climate change adaptation is a pertinent issue for the people of Ruby and their subsistence livelihoods. The people of Ruby have experienced incredible social changes during the course of the last six decades, largely as a consequence of European contact and colonization. Analysis of adaptation to historical change experienced since the 1950s can provide insight into the ways in which the present social and political context shape vulnerability to the impact of climate change. For example, the role of dependency on cash and fossil fuels and imposition of fish and

wildlife regulations resulting from past social changes constrain people's ability to respond to ecological change and therefore vulnerability to climate change.

As issues of justice in climate change adaptation are increasingly brought to the forefront, acknowledging the influence of the political context for adaptation becomes a necessity. Human communities differ in their ability to respond to the impacts of climate change (Adger 2006) and adaptation to the biophysical impacts of climate change has the capacity to aggravate and reproduce existing vulnerabilities (Adger et al. 2006; Mearns & Norton 2010). The injustice of climate change for indigenous peoples has at least three dimensions. First, indigenous peoples have contributed the least to the causes of climate change (Crate & Nuttall 2009). Second, they are among the first to be impacted due to their close connections to their local ecology through subsistence livelihoods (Kassam 2009). Third, as this study illustrates, the legacy of colonialism presents political barriers that can make indigenous communities more vulnerability to the impacts of climate change.

The impact of fish and wildlife regulations on the people of Ruby's ability to respond to ecological change has been raised in this case study as an example of a political barrier to adaptation. Although the regulation of subsistence livelihoods for Alaska Natives and the impacts of native self-determination has been hotly contested since Alaska Statehood and thereafter through ANCSA and ANILCA (Berger & Alaska Native Review Commission 1985), climatic impacts on subsistence add further relevance to these existing criticisms. Further research should be done to examine alterative institutional arrangements that might address the current lack of flexibility and local control in harvesting regulations, while at the same time ensuring the

conservation of subsistence species such as moose for present and future generations. Given the long-term struggle on the part of Alaska Natives to gain control over subsistence harvesting, the convincing both state and federal agencies to alter the current power sharing arrangements is likely to be a significant hurdle to increasing local control over subsistence livelihoods, through the implementation of co-management agreements or otherwise. This reality makes future research in this area even more pertinent.

***Conclusion***

Climate change adaptation is an important issue for indigenous peoples and their subsistence livelihoods, which are closely connected to the local ecology. The people of Ruby have faced tremendous changes in the last half-century. Seasonal rounds and narratives comparing subsistence livelihood in the 1950s to contemporary practices illustrate many of these changes. Their responses to historical changes, including sedentization, increased contact with the market economy and the creation and enforcement of subsistence harvesting regulations demonstrates their resilience and determination to continue to practice subsistence livelihoods. At the same time, research findings indicate adaptation to these past social changes have bearing on their present vulnerability to the impacts of climate change. Furthermore, this analysis raises many ethical considerations as the present political context, resulting from a history of colonialism, can constrain indigenous peoples' ability to respond to the impacts of climate change in the manner of their choosing. As such, research findings reveals that adaptation to climate change is not solely about understanding and responding to the directly observable impacts of climate change on subsistence

livelihoods, it is also about understanding and addressing how the manner in which the broader political context can make communities more or less vulnerable to the impacts of climate change.

# CHAPTER 3
# INDIGENOUS WATER SOVEREIGNTY AND THE HUMAN ECOLOGY OF WATER IN RUBY VILLAGE, AK

> To speak of indigenous peoples and water is to speak of cultural diversity. Original inhabitants share the same philosophy about water, but they practise diverse forms of water management, according to their own differing realities, histories and experiences. In the indigenous world, there is no single 'model' for using water resources, but multiple alternatives and forms of management that change from region to region and from time to time. The common element underlying these diverse forms of water management is 'respect for water', considering water resources not as an input or a commodity, but as a living part of Nature, as a being with which one must interact in order to ensure the rights and participation of all living beings. (Pablo Solón, Bolivia's former U.N. Ambassador, in Boelens et al. 2006, p.37)

## *Introduction*

Water is essential to all forms of life. Across the globe, communities and nations are increasingly affected by the occurrence of water crisis globally caused by both scarcity and impaired water quality (Barlow 2009; Gleick & Cooley 2009; Rosegrant et al. 2002). In response, water security is being promoted to the top of local, national and international agendas (Bakker 2009; Bakker & Cook 2011; Cosgrove 2003; Jones 2009; NRC 2007; Waughray 2011). Water security is defined as the sustainable access to adequate water quality and quantity to ensure the wellbeing of human communities, economies and the environment (de Loë et al. 2007; Norman et al. 2010; Schultz & Uhlenbrook 2008).[17] The basic rights approach inherent in the concept of water security is not sufficient to address the relationship between indigenous peoples and water.

[17] Water security has also been used to refer to the protection of water as a national security issue. This approach is concerned with the protection of water and water infrastructure from terrorist attacks or ensuring national interests in the context of transboundary or international watersheds (Norman et al. 2010; NRC 2007).

Water is fundamental to the material and cultural survival of indigenous peoples (Barbera-Hernandez 2005), whose diverse relationships to water are based on distinct worldviews, as indicated by the quote above by Pablo Solón. Similar to the unique socio-cultural relationships indigenous peoples maintain with other elements of their environment,

> water is intrinsically tied to their distinctiveness and to the protection that the recognition of that distinctiveness entails. Not only is the right to water intrinsic to the right of indigenous peoples to survive as human beings but, also, the *manner* in which the right is exercised, i.e. according to traditional mores and customs, is part of their culture and also deserving of protection as a human right. Inevitably, in the case of those communities the protection of the right to water includes respect for existing patterns of traditional use and management. (Barbera-Hernandez 2005, p.6)

Although definitions of water security have become increasingly holistic over the last fifteen years (Norman et al. 2010), the basic needs approach inherent in the concept of water security lacks the capacity to acknowledge the diverse ways that indigenous communities relate to and value water in order to meet both their material and cultural needs. The objectives of this paper are to demonstrate the need to go beyond the concept of water security given the people of Ruby's specific relationship to the Yukon River, its tributaries and associated aquifers; to develop a concept of water sovereignty that is responsive to indigenous peoples' multifaceted socio-cultural and ecological relations to water; and to provide recommendations for future applications of the concept of water sovereignty.

*Conceptualizing Water Sovereignty*

The ability to relate to water and other resources in the manner of their choosing is a fundamental sovereignty issue for indigenous peoples (Boelens et al. 2006a). Failure to acknowledge this relationship to water is in contradiction with the

United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), which affirms the rights of Indigenous peoples' to their 'lands, territories and resources' (Article 26), including the right to determine how these lands, territories and resources, of which water is a part, will be developed (Article 32) (2008).

The concept of sovereignty is complex and has been defined in many ways. The modern model of sovereignty assumes that states exercise "supreme authority within a territory" (Philpott 2010). However, indigenous peoples' struggles against colonialism highlight several problems associated with the assumption that states are the primary actors to exercise sovereignty (Shaw 2008). Bruyneel (2007) proposes that indigenous peoples' occupy a 'third space of sovereignty', a term that acknowledges the complex ways that indigenous peoples' negotiate their sovereignty in spite of imposed boundaries, thereby rendering state borders a site of resistance rather than colonial oppression (25). Furthermore, the ways that indigenous peoples' have asserted their sovereignty in the negotiation of multiple and complex relationships with state, federal and other tribal governments illustrates that the autonomy/dependency dichotomy created by the notion of sovereignty as complete authority is overly simplistic. Instead, Cattelino (2010) states that indigenous peoples' struggles allow us to develop a concept of sovereign interdependency, where sovereignty is achieved through relationships. This concept is also useful for breaking down the myth that it is possible for states to exercise complete sovereignty and reveals how states too maintain a relational sovereignty in their interactions with various actors including other states, the global economy and indigenous peoples (Ibid.). In order to capture the complex ways that indigenous peoples negotiate their

sovereignty, this paper defines sovereignty broadly as the "collective assertions, everyday enactments, and lived experiences of political distinctness" (15).

Extensive literature documenting the food sovereignty movement contributes to the incipient conceptualization of water sovereignty (Campesina 1996; Declaration of Atitlán 2002; Menezes 2001; Mousseau 2005; Windfuhr & Jonsén 2005). The food sovereignty movement emerged in response to the national and international trade policies that privilege industrial over local food systems (Windfuhr & Jonsén 2005). The movement, *Via Campensina,* an alliance of peasants and smallholder famers*,* first coined the term food sovereignty in 1996 (Menezes 2001). The food sovereignty literature demonstrates that food security is subject to the same critiques as water security. Socio-cultural and ecological choice is central to the ability of indigenous peoples to meet their needs and therefore food sovereignty is a prerequisite for food security (Menezes 2001). Kassam et al. state that "[u]nlike food security, which suggests access to food to meet minimum nutritional needs, food sovereignty encompasses the right and ability of individuals and groups to choose their own food based on the socio-cultural and ecological systems they inhabit" (2010, p.817). The notion of cultural choice, or the ability to choose based on their socio-cultural and ecological relations, inherent in food sovereignty is absent from definitions of water security. The development of a concept of water sovereignty, which acknowledges the value of cultural choice and other pertinent elements, is made possible through analysis of the human ecology of water within a given context.

*The Human Ecology of Water*

The complex and multifaceted relationships between humans and water is the

subject of an extensive and interdisciplinary literature (Orlove & Caton 2010; Strang 2004; 2009). The totality of the relationships between people and water in a given society, or hydrologic connectivity, is referred to as a "waterworld" (Hastrup 2009), a concept that implies human interactions with water can delineate the borders of human communities (Orlove 1993; Orlove & Caton 2010). Human relationships to water are simultaneously comprised of both material and socially constructed dimensions. The materiality, or elementality of water, refers to the physical properties that structure relationships between humans and their environment and influence human concerns related to water quality and quantity. The ways these relationships to water are socially constructed, or ascribed meaning and values within a given context, and the manner through which these meanings influence peoples actions must also be considered (Orlove & Caton 2010). According the Jessica Budds, these "social relations [to water] – played out through diverse artefacts and institutions such as hydraulic infrastructure, water laws and policy discourses – shape how water flows through the waterscape, yet are also themselves shaped by water" (2009, p.420). In other words, the hybrid or 'hydrosocial' nature of water is revealed through the existence of both the material and socially constructed dimensions of water, and the interactions between the two (Budds 2009).

Viewing water from a human ecological perspective allows us to understand the complex interrelations between both the material and socially constructed dimensions of water in a specific context. Human ecology examines "the relationships between people and their environment, which includes relations between humans and human relations with other animals, plants, and their habitats" (Kassam 2009, p.65).

Literature on the relationship between people and water often relies on a problematic dichotomy between nature and culture (Strang 2004), or the material and socially constructed dimensions of human relations to water. Human ecology conceives of relations to water within a complex set of socio-cultural and ecological relations where the environment fundamentally informs cultural systems in a non-deterministic manner (Kassam 2009). A human ecological perspective does not separate material from the socially constructed dimensions relations to water and therefore allows us to collapse the false dichotomy between nature and culture.

Human ecology provides a lens through which to study the complex relationship between indigenous peoples and water. As described above, indigenous peoples maintain unique and complex relationships to water. Water occupies a central role in indigenous cultures including livelihood practices, spiritualities and cosmologies (Boelens et al. 2006b). Furthermore, similar to indigenous peoples' relationships to land, relationships to relationships to water arise from long-term use and occupancy of a given traditional territory which is "their source of livelihood and sustenance and the basis of their very existence as communities" (Section 14, Stavenhagen 2005). The development of the concept of water sovereignty rests on the existence of indigenous peoples' specific relationships to water and the importance of these relationships to their cultural continuity and self-determination. The concept of water sovereignty, and the cultural choice implied by this term, demands further analysis of the multifaceted relationships between indigenous peoples and water. Through a case study of the socio-cultural and ecological relationship to water maintained by the people of the Koyukon Athabascan Village of Ruby, AK, this paper

aims to develop a concept of water sovereignty.

***Context***

Ruby Village is situated in the middle river region of the Yukon River (64°44'22.00"N, -155°29'13.00"W) (Figure 19). The village is located in the Ruby Creek sub-Watershed (1,087acres) on the south bank of the Yukon River between the Villages of Tanana and Galena, adjacent to the Nowitna National Wildlife Refuge in the Kilbuk-Kuskokwim Mountains. This region, located in the interior of Alaska, is characterized by plentiful streams, rivers, lakes and sloughs, wetlands, open spruce forests and shrublands. This landscape diversity provides habitat for a rich variety of fish and wildlife including salmon, moose, diverse species of migratory waterfowl, bears, wolves, beaver and other small game (YRITWC 2002). While the area around Ruby Village has been part of the traditional territory of the Koyukon Athabascans for millennia, the settlement itself was founded as a supply point for gold prospectors during the mining booms of 1906 and 1910 (Larson 2006). The gold strikes attracted thousands of prospectors to the area, however, after WWII most of the miners had moved away and Ruby became a native village (ADCRA 2010). The current population of Ruby is 166 persons, living in 62 households. The local residents are 88.6 percent American Indian or Alaska Native (U.S. Census 2010).

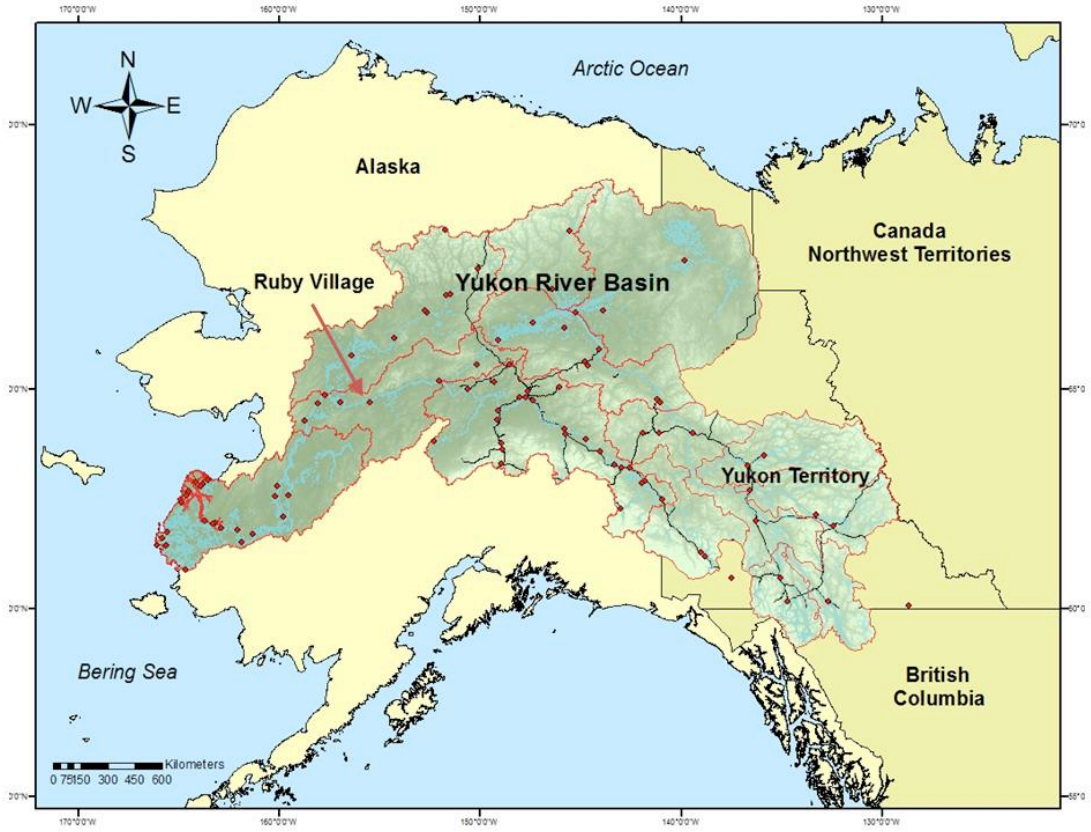


**Figure 19 Map depicts the location of Ruby Village in the Yukon River Basin**

Beginning in the 1960s, the political struggles of indigenous peoples in the Arctic and Subarctic of North America, such as the people of Ruby, have focused on land claims and subsistence rights (Berger & Alaska Native Review Commission 1985; Brody 1982; Feit 1995; Nadasdy 2003). Whereas legal doctrine addressing indigenous water rights tends to develop to a greater extent in contexts of scarcity, for example, *Winters Doctrine* in the arid Western United States (Pevar 2002), in the North American Subarctic and Arctic, discussions of water issues have with few exceptions been treated implicitly within other political struggles.[18]

[18] The Mackenzie River Basin Transboundary Waters Master Agreement and corresponding Mackenzie River Basin Board does not explicitly include native water rights, but includes

The Yukon River and its tributaries are defining features of the landscape and are complexly interconnected with the lives and livelihoods of its indigenous residents (Nelson 1986). The current threats to water resources in these contexts, including pollution and climate change, and their socio-cultural and ecological impacts demand that water issues for indigenous peoples be brought to the forefront (YRITWC 2002). The following section describes the methodologies used to study the human ecology of the people of Ruby.

***Methodologies***

Participatory Action Research (PAR) is an iterative approach to research used to generate knowledge through cycles of action and reflection (Greenwood and Levin 2008). Furthermore, PAR is a fundamentally ethical research philosophy that informs research methods and design in order that science can serve as the basis for social change (Greenwood and Levin 2008). Community collaboration in all aspects of research design and implementation is vital to PAR and contributes to the goal of affecting social change (Kassam 2009). Participatory approaches are especially well suited to the study of indigenous knowledge because they integrate reciprocity, which is integral to reducing the risk that research will reproduce colonial relationships between the researcher and research participant. Moreover, the attributes of indigenous knowledge, such as context specificity and complex connectivity to socio-cultural and ecological systems make participation a necessity (Kassam 2009).

This research project strives towards the ideal of PAR. The study can be characterized as participatory in the sense that it was designed and conducted in

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First Nations, their knowledge and values within a governance arrangement that acknowledges existing treaty rights (The Government of Canada et al. 1997).

partnership with the Yukon River Inter-Tribal Watershed Council (YRITWC), whose goal is to meet the needs of the seventy indigenous governments in the Yukon River Basin they serve. Furthermore, the YRITWC facilitated a research partnership with the Ruby Tribal Council (RTC) and the project was modified to fit the context of Ruby Village. All research data and outputs were validated by and shared with the RTC and the YRITWC (Figure 20). Working directly with community members to determine research objectives and design, rather than just the YRITWC, will strengthen future attempts at participatory research.

Research was conducted during two field seasons. The first of these field

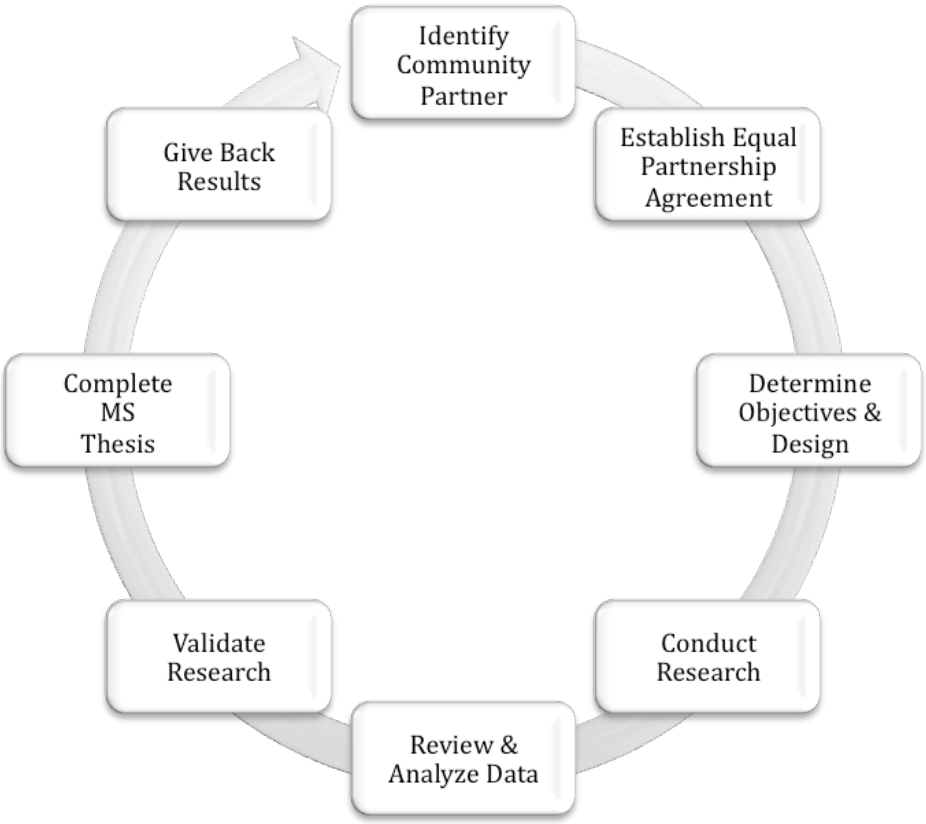


**Figure 20 Participatory Research Design depicts the stages of the research process carried out in partnership with the Yukon River Inter-Tribal Watershed Council**

seasons took place between June and October 2010 and the second in July and August 2011 (Figure 21). During this time, semi-structured interviews were conducted with 20 community experts, including Elders, subsistence harvesters and tribal administrators.[19] This included eight women and twelve men who ages ranged from 49 to 92 (Appendix A). Interview participants were recruited using a snowball method where contacts at the Ruby Tribal Council were asked to make a list of the community experts who could contribute to the research (Patton 2002). Community experts were added to the initial list when referred by other interview participants.

Interviews were conducted using an iterative process. A minimum of three meetings was held with each interview participant.[20] Interviews focused on the use and perception of water, among other topics, largely related to the subsistence livelihoods maintained by the people of Ruby. Interviews were conducted in two parts. During an initial interview, participants were asked to describe their how they use and value water, including specific questions related to drinking water, subsistence livelihoods and their perception of the Yukon River. Specific follow-up questions were asked to clarify responses. Interviews were documented using written field notes rather than audio recordings. The author wrote a narrative essay based on interview field notes.

Typed versions of interview narratives were validated during a second interview. Interview narratives were read out loud to the interview participant. At the

[19] Community experts were selected based on recommendations from other members of the community. Each of the community experts was heavily involved in subsistence practices and had lived in Ruby for an extended period of time, if not their whole life.
[20] All community experts were visited a minimum of three times. However, at the request of the community experts, additional visits were paid and further information was added to interview narratives as needed.


**Figure 21 Conveys the iterative research process followed when conducting research in Ruby Village. Each community expert was visited a minimum of three times over the course of five research trips to Ruby Village.**

time of validation, changes were then made to interview narratives to correct data or to add other important information that was left out during the initial interview. During a third visit, final printed versions of final of interview narratives were given to each participant for their records. Interview narratives were coded for observations of change using Text Analysis Mark-up System (TAMS) Analyzer, a qualitative data analysis tool.

Human ecological mapping was conducted as part of interviews. Interview

participants were asked to place icons representing key species, livelihood activities,[21] and drinking water sources on a 1:250,000 scale topographic map encompassing the traditional territory of the people of Ruby Village. This map was then digitized using ArcGIS. A printed version of the digitized map was then presented to interview participants during follow-up interviews where additional icons and place names were added and feedback regarding the layout was gathered. Research results were then presented for validation during a public meeting held in July 2011. Community experts consented to having their names used in this research. Their names are used as a form of citation and to recognize the contribution their knowledge has made to this research.

***Results and Discussion***

The people of Ruby maintain multiple and complex relations to water. Water is essential to all aspects of life in Ruby Village. While the 'essentiality' of water is not distinct from other human communities, the specific socio-cultural relations to water maintained by the people of Ruby are. The following describes the relations between the people of Ruby and water including and some attributes that make these relations unique.

The Yukon River, its tributaries and associated waters are important to the people of Ruby in multiple and complex ways. Community expert George Albert stated

[21] Icons were borrowed from previous human ecological mapping projects conducted in Wainwright, Alaska and Hay River, Northwest Territories (Kassam & Soaring Eagle Friendship Centre 2001; Kassam & Wainwright Traditional Council 2001).

> The Yukon River is important in a lot of ways, I guess. We travel on it to get back and forth. In summertime we do what I am doing now. We go up the river to get a raft of wood. I do this three to four times a season. People also fish on the river. I don't do this so much myself anymore. The river is important for hunting. Everything we hunt is on the river. Sometimes people go out the road [to hunt], but mostly it's on the river. Most of my trapping camps are on the river.

Research findings reveal that water, including the Yukon River, its tributaries and associated surface and subsurface waters are used in the following ways: transportation, habitat for subsistence species, drinking water, sanitation, spiritual, recreation and other domestic uses such as watering gardens (Table 4).

Water is not valued for these uses alone. The people of Ruby value water for economic, ecological and cultural reasons and these values converge in the practice of subsistence livelihoods. Similar to other indigenous peoples, for the people of Ruby, subsistence livelihoods are not only a means to meet their basic nutritional needs, but they are also viewed as the basis for their traditional 'way of life' or culture (Wheeler & Thornton 2005). Defining subsistence in this manner reveals the materiality and socially constructed nature of water are intricately intertwined within distinct socio-cultural and ecological relations to water.

The land use pattern that emerged from human ecological mapping demonstrates the relationship to water is intimately intertwined with subsistence livelihood practices, which connect the people of Ruby to an extensive traditional territory (Figure 22). The people of Ruby rely on a wide variety of subsistence species to meet their nutritional needs (Appendix C). Icons indicating the harvest of important subsistence species are largely concentrated along the rivers and other bodies of water. The importance of rivers, sloughs and associated riparian areas as habitat for subsistence species makes explicit the connection between water and food. For

**Table 4 Describes the multiple uses of water by the Koyukon Athabascan people of Ruby Village, AK**

| Uses of Water in Ruby Village, AK | |
|---|---|
| **Use** | **Description** |
| **Transportation** | Since Ruby Village is not located on the Alaska road system, the Yukon River is the main transportation corridor for Ruby Residents. People travel on the river by boat during times of open water and by snowmobile when it is frozen over in the winter months. The barge system is the main way that supplies are transported to Ruby. People also travel on the Yukon River and its tributaries for all subsistence livelihood activities including hunting, trapping and fishing. |
| **Habitat** | The Yukon River and its tributaries provide habitat for subsistence species relied upon as a source of food including fish, such as salmon and riparian habitat used by many other animals, such as moose. Wetlands also provide important habitat for gathered berries including blueberries, cranberries and salmon berries. |
| **Drinking Water** | Drinking water is taken from the Yukon, its 'clear' tributaries, or a stream with minimal sediment loads, and ground water from springs and wells. |
| **Spiritual** | One elder mentioned the use of hot springs near Ruby for healing. The overall relationship to water is a spiritual one that requires that people pay the same respect for water as they do all other living beings. |
| **Recreation** | The Yukon and its tributaries are used for recreational purposes. Swimming is the main recreational use of water. |
| **Firewood** | Large quantities of driftwood are transported by the Yukon River each year by the high waters that occur during and after spring break-up. This driftwood represents an important source of firewood for the people of Ruby. It is gathered in the spring and dried for later use during the winter. |
| **Sanitation** | Water from the municipal water supply and private wells are used for washing and bathing while in the Village. Other sources are used for this purpose when people are at fishing, hunting and trapping camps. |
| **Watering Gardens** | Approximately a dozen households in Ruby maintain a small vegetable garden. Water for these gardens was taken from various sources. The public spring located in Ruby is used for this purpose. While the spring is contaminated by fecal coliform bacteria, which it unsuitable for drinking it is safe for watering gardens. Water from the Yukon River is also used, although it is known that you cannot use it too often because of the high level of sediment in these waters. Water from the municipal supply or private wells is also used. |

example, moose and salmon are essential to the food security of the people of Ruby as they make up a significant proportion of their diets. The general land use pattern also illustrates the continued use of rivers as the main transportation corridors us by the people of Ruby in the course of subsistence livelihood activities. Finally, icons representing drinking water sources show that various sources of drinking water including springs and rivers are distributed throughout the landscape as they are used in the course of subsistence harvesting, while people are away from the main village site. In general, the pattern formed by the icons throughout the landscape demonstrates the spatial distribution of the uses of water described above. The following section examines the *complex connectivity, context specificity* and *dynamic and adaptive* aspects of these relations in Ruby Village.

*Complex connectivity*

Complex connectivity signifies a sense of 'kindredness' with all aspects of the ecology, which creates no separation between people, water and land (Kassam 2009, p.85). This stands in contrast to instrumental connectivity to water, which fails to acknowledge to complex material and socially constructed meanings of water. Complex connectivity is illustrated through the relationship to the Yukon River. The Yukon River is the most prominent feature on the landscape. The people of Ruby rely on the river for all aspects of their lives and livelihoods. The quotes below illustrate

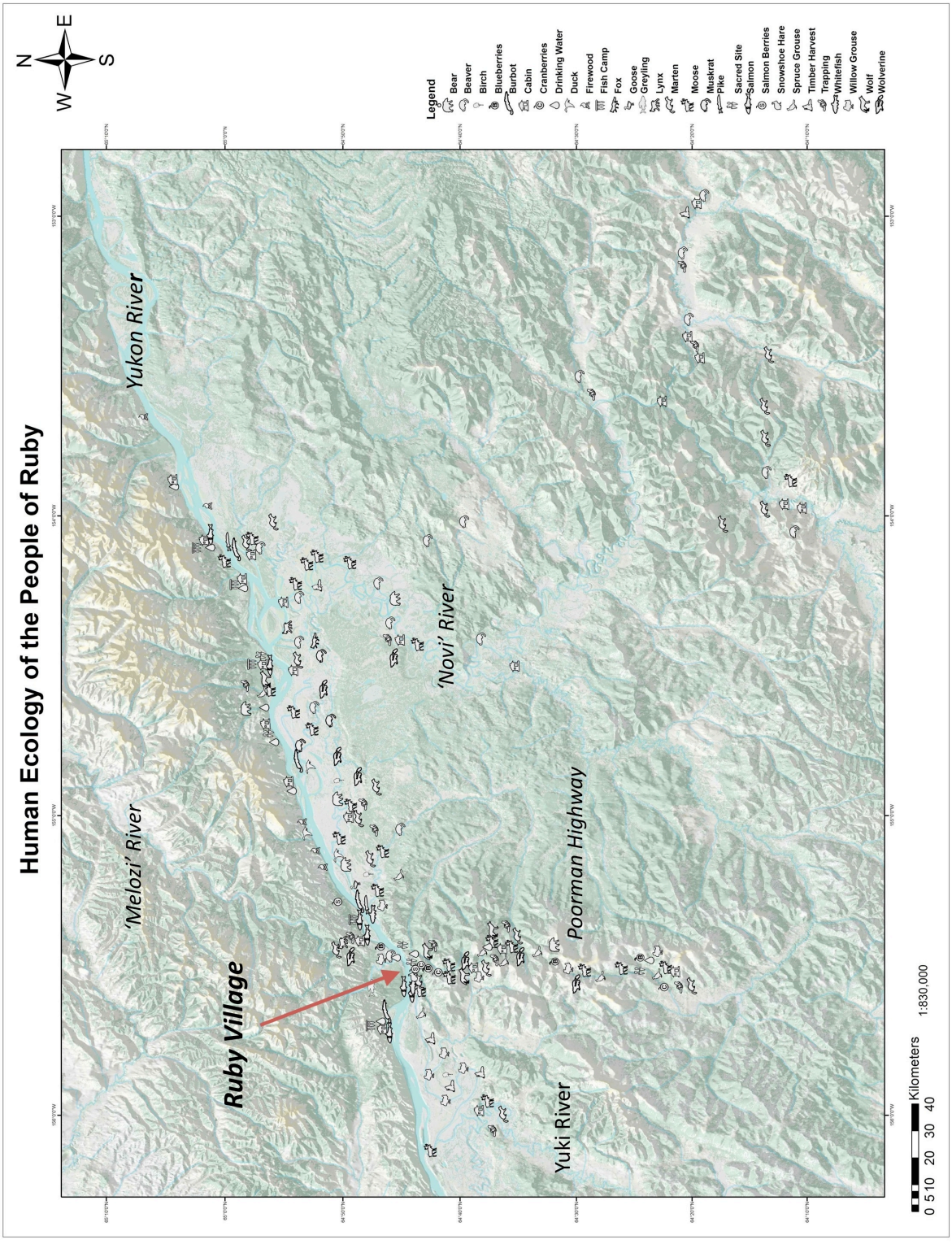


**Figure 22 Human ecological map of the people of Ruby Village illustrates present use of land and water.**

their complex connectivity to the Yukon River:

> The Yukon River is life itself for the people of Ruby. It brings life and it brings death. It feeds us. It's a transportation highway in the winter. It is full of fish in the summer. (Edna Peters)
>
> We have lived so long on the river. It's part of our family so we treat it that way. (Tom Esmailka)
>
> The Yukon River is important to us for a number of reasons. We use it for fishing and transportation. It's just a place that people are drawn to go swimming and just to be by the river. People go down by the river because it's a peaceful place. They go down to see the barge come in. It is also a hunting route. I use the river a lot for hunting. I have better luck on the river in my boat [than on the road]. It's good just being on the river. It's a good place to go. I have a real connection to the river that way. (Ed Sarten)

Finally, Elder Martha Wright discussed the cultural and spiritual relation to the Yukon River. She stated, the people of Ruby do not "worship the river, we respect the river," as they do all other living beings. Koyukon notions of respect have been well documented (Nelson 1986). Respect is discussed largely in the context of reciprocal relationships to beings, such as animals, that are attributed personhood. On the Koyukon relationship to rivers, Nelson (1986) states "[a]lthough rivers are paramount features of the Koyukon landscape, they are not regarded as great sources of supernatural power. Nevertheless, they do have consciousness that at one time of year [during spring break-up] must be supplicated" (36–37). Whereas water is often treated as an abiotic, or non-living element of the physical world, the notion of respect invoked by Martha Wright seems to indicate that water, in this case the Yukon River, can also be considered living or animate. This notion of respect means that the Yukon River is not valued instrumentally, or merely for its importance as a means of obtaining the minimum ends of human life. Instead, the views expressed by

community experts and the indicated notion of engagement within reciprocal relations of respect with the river, indicate the deep cultural importance of the river characteristic of complex connectivity.

*Context Specificity*

Context specificity refers to the manner in which relations to water are particular specific groups of people who occupy a defined territory. Relations to water are embedded within a web of interactions including those between humans, animals, plants and other abiotic features of the landscape such as water. Therefore, social relations to water are fundamentally informed by their ecological context (Kassam 2009, p.85). The various uses of water described above connect the people of Ruby to many bodies of water within their traditional territory including the Yukon River and its tributaries, the Melozi, Nowitna ('Novi'), and Yuki Rivers, and numerous sloughs, lakes, springs and associated aquifers. Furthermore, they are connected to the larger hydrologic system due to their location in the Yukon River Basin and interactions with atmospheric conditions and the influence of temperature and precipitation on their local hydrology. In other words, shared social relations to water, such as those represented by the collective practice of subsistence livelihoods, create linkages between people who reside within specific geographic regions, but also connect these communities to populations outside their 'local' context through the global hydrologic cycle.

The people of Ruby's human ecological relations to water are specific to their socio-cultural and ecological context. Elder Martha Wright reveals some important dimensions of these relations through her observations of the interactions between

streamflow, currents and sediments in creating ideal fishing conditions:

> When the water is low, my spot gets filled up with sand. It's a hole and it creates an eddy where the water will turn and go up stream. It's where the fish come in to rest. That is an eddy. Ruby is having high water right now. It's good because it's washing out the eddy [at my fishing site]. It cleaned out the silt. […] I was getting worried because it would eventually disappear.

The quote reveals both the biophysical and socio-cultural dimensions particular to the context in which fishing takes place. The biophysical properties of water influence both the species present in a given habitat and the technique that is used to fish for them. For example, salmon and grayling depend on distinct habitat types and are generally caught using fish wheels and gillnets and fishing poles, respectively. At the same time, fishing is also influenced by socio-cultural relations for example those that determine individual access to certain fish camps or sites. Fishcamps and sites are maintained as exclusive and private among the people of Ruby. While Yukon River people did not have family or individual territories prior to European contact, ownership of fishing sites has always been treated in this way (Sullivan 1942). The biophysical and socio-cultural dimensions of relations to water pertaining to fishing demonstrate the context specificity of socio-cultural and ecological relations to water in Ruby Village.

*Dynamic and Adaptive*

The people of Ruby have developed relations to water through long-term use and occupancy within a given territory. These relations are cumulative and require the people of Ruby not only to be conscious of present ways of relating to water, but also relations to water maintained by the generations that went before them. However, relations to water based on traditions are not fixed in a particular historical period.

They are dynamic and the practitioners of these traditions are capable of adapting to change (Kassam 2009).

The example of evolving perceptions of drinking water demonstrates the dynamic and adaptive nature of relations to water in Ruby Village. Throughout history, the people of Ruby have collected drinking water from a variety of sources depending on their location, the season and a variety of other factors. Traditional sources of drinking water include the Yukon River, three of its main tributaries including the 'Novi' (Nowitna) River, the 'Melozi' (Melotzina) River and the Yuki River, several smaller tributaries or 'clear creeks,' springs and aquifers. Certain techniques for obtaining water for drinking and other domestic purposes are not practiced anymore. For example, in the summer when there is a high sediment load, people used to collect water from the Yukon River by digging a hole on the beach that would fill with clear water that was suitable for drinking and other uses. In the winter, when the sediments have largely settled out of the River, people would dig a hole in the ice and use a bucket to obtain drinking water. It is no longer common for people to practice either of these methods for obtaining drinking water.

Two major historical changes have influenced socio-cultural relations to drinking water. First, sedentization, or the shift from a movement on the land based on seasonal changes to living in a centralized village location meant that community members were relying on fewer drinking water sources when they were in the Village. Second, the introduction of technology in the 1970s that allowed access to groundwater through private and municipal drinking water wells to the residents of Ruby Village through a municipal water supply beginning in the late 1970s and other

private wells was cited as another major change. Many community experts cite the convenience of well water as a factor that reduces the likelihood that they will obtain water from other sources. However, the increased reliance on municipal water supplies does not negate the use of traditional water sources or the socio-cultural relations to them. Community experts indicated that they continue to consume water from a wide variety of traditional sources. Water is consumed from small 'mountain' creeks and springs when people are out on the land hunting and trapping or while in fish camp. Water from these sources, especially springs, is preferred to water from the municipal water supply as it is considered healthier and does not have the taste that accompanies chlorination treatment. The continued use of traditional drinking water sources is influenced by a variety of factors including the extent to which people spend time on the land and the knowledge individuals have of these traditional sources of drinking water.

Land use patterns can also illustrate important dimensions of the dynamic and adaptive nature of relations to water in Ruby Village. The general pattern of land use indicated by the human ecological map of the people of Ruby reveals intensive use of the Poorman Highway. The Poorman highway leads to Long Creek, the site of the mining boom of 1910. It was initially a wagon trail used to transport people and supplies to and from the mining camp. Although mining in the area has largely ceased, the Poorman Highway continues to exist as a regularly maintained gravel road. The Poorman Highway is not connected to the Alaska road system. Many peoples hunting camps and native allotments are located along this route. Where as the rivers used to

be the only transportation corridor, the use of the road is now also used intensively in the course of participating in subsistence livelihoods.

The intensive use of the Poorman Highways might be indicative of how social relations to water could change if the Village of Ruby where ever to be connected to the Alaska Roads system. Cruikshank (1985) discussed the role of roads as 'gravel magnets' based on the social impacts of the construction of the Alaska Highway. In the Yukon Territory prior to the 1950s, indigenous peoples' land use patterns revolved around the river system, but the construction of the 1950s radically altered this pattern as it concentrated human settlements along the road system. This change in land use was not merely a response to the construction of the roads system, but also to the broader social changes that were occurring at the time as a consequence of colonization. Despite the current use of the Poorman Highway, the people of Ruby continue to rely heavily on the river system for all aspects of subsistence livelihoods. However, if the village were ever to be connected to the roads systems it is likely that further changes in land use would be observed.

The unique socio-cultural and ecological relations between the people of Ruby and water are illustrated by the above discussion of *complex connectivity*, *context specificity* and *dynamic and adaptive* character of relations to water. Community experts identified climate change and environmental degradation as factors affecting their relations to water resources.

*Climate-Induced Hydrologic Change*

The people of Ruby observed a number of changes in water resources that may be linked to global climate change. According to Phillip Albert "[t]he temperature has

changed and it doesn't get as cold anymore. His dad told them stories when they used to go trapping. It would be 40 to $50^0$ F below for days and they would still have to go out trapping. It isn't like that anymore." In addition to the trend toward increasing temperatures, changes in precipitation, break-up, freeze-up and ice thickness on the Yukon and other rivers were also observed. Lily Sweetsir has observed changes in the ice regime of the Yukon River:

> There has been a change in spring break-up on the Yukon. It goes out at the same time in May, but the difference is in the ice. The sound it used to make was tremendous. Now it doesn't make that noise. Freeze-up starts in October, but you have to wait until it is cold enough in November or December. In the old days you still had to wait a long time. Sometimes it freezes in November. It depends.

These changes are likely linked to global climate change and correspond to the climate trends documented in scientific literature (ACIA 2004). The causes of climate change are largely beyond the control of the indigenous peoples of Ruby (Crate & Nuttall 2009), however, there is great concern regarding the potential impacts of climate change on socio-cultural and ecological relations to water. For example, changes in river ice regimes, such as those observed above, threaten the safety and access of those who use the river as a transportation corridor when it is frozen over in the winter.

*Environmental Degradation*

The people of Ruby expressed concerns about environmental degradation and the contamination of water resources from a variety of sources including old mining sites, municipal sewage and the Ruby landfill. People are concerned about the human health impacts of consuming contaminated drinking water and subsistence species. Tom Esmailka stated

> some people drink water out of the Yukon. I drink it. Some people say it's a bad idea. But I take the water because when you are thirsty you are thirsty. I drink water from it. I make tea out of it. Drinking contaminated water isn't good, but we live here on the river and we don't always have a choice.

The Ruby Tribal Council's environmental program has made a concerted effort to address and raise awareness about environmental problems such as the leaching caused by putting lead acid batteries in the landfill. At the same time, the sources of other contaminants are beyond the control of the people of Ruby. For example, municipal sewage and mining waste originating upstream from Ruby or those resulting from atmospheric deposition, which come from locations outside of Ruby and possibly even outside of North America (Kallenborn & Berg 2007). The reality is that the causes of climate change and many sources of contamination are well beyond the control of the people of Ruby and yet they impact every aspect of their lives and livelihoods. The following discussion of water sovereignty arises largely in response to the threat these alterations in water resources pose to the socio-cultural and ecological relations to water maintained by the people of Ruby Village

*Indigenous Water Sovereignty*

Through the analysis of the people of Ruby's relationship to the Yukon River, its tributaries and associated aquifers this paper seeks to demonstrate the need to go beyond the concept of water security. Given the attributes associated with indigenous peoples' relations to water and previous definitions of food sovereignty, *water sovereignty is conceptualized as the right and ability of individuals and groups to define their own relationship to water in a manner consistent with the socio-cultural and ecological systems they inhabit.* Water sovereignty includes protection for various

uses of water and ways of relating to specific bodies of water, which are intimately a part of a way of life and the traditional territory of indigenous peoples. Research findings from Ruby Village reveal that there are several elements pertinent to achieving indigenous water sovereignty including indigenous water rights, cultural choice, ecological knowledge and ecological possibility (Wilson et al. 2011) (Figure 23). The following section defines these elements in relation to research findings from the human ecological research in Ruby Village.

*Indigenous Water Sovereignty*

Indigenous water rights are one component of water sovereignty. This discussion of water rights begins from the belief that indigenous peoples are the holders of *inherent water rights* that

> flow from the relationship of Indigenous Peoples to our traditional territories. Our right to water is an inherent right arising from our existence as Peoples and includes a right of self-determination with the power to make decisions, based upon our laws, customs, and traditional knowledge to sustain our water, for all life and future generations. (Walkem and Schabus in Phare 2009, p.46)

In other words, water rights are not conferred upon indigenous peoples by colonial governments, "[t]ribes exercise rights based on their original and indigenous sovereignty" (Wilkins 2001, p.121). While these rights do not lose their meaning when unrecognized by colonial governments, acknowledgment by other legal regimes can make inherent rights more effective. Any discussion of water rights for indigenous including water rights for the people of Ruby and elsewhere in the Yukon must be situated within the complex legal and political landscape of Alaska. The following

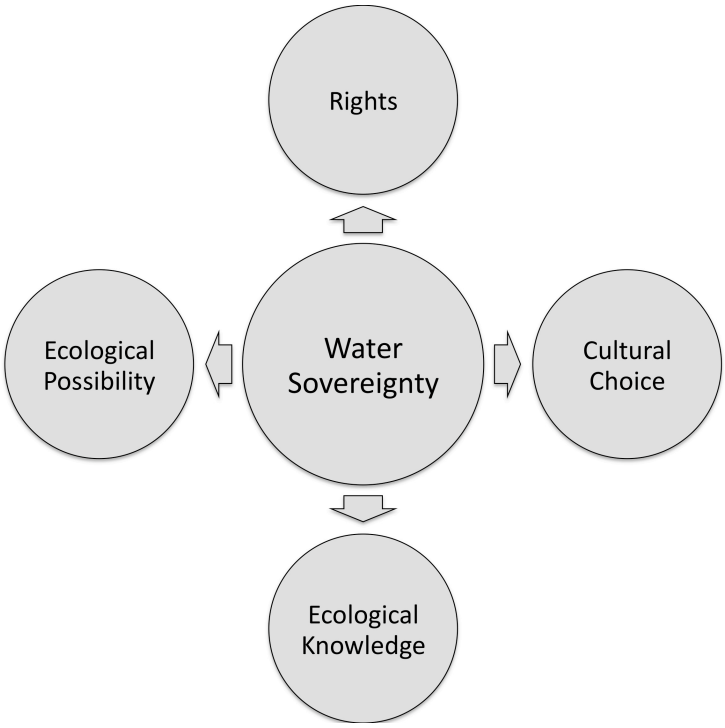


**Figure 23 Illustrates the elements of water sovereignty including rights and the possibilities that allow people to exercise these rights including cultural choice, ecological knowledge and ecological possibility**

provides a brief overview of the legal context in Alaska and should not be considered a comprehensive review.[22]

The United States has long recognized indigenous water rights on the basis of historical use and occupancy and treaties. The *Winters Doctrine* was established through what is widely considered the most important Indian water law case in the United States, *Winters v. United States* (1908) (Pevar 2002; Ranquist 1975; Shay 1992; Shurts 2000). While the implementation of these rights has been complicated and in practice has failed to benefit Indian lands (McCool 1994), this case recognized

[22] All aspects of my research on indigenous water rights in Alaska are informed by the research conducted by the YRITWC's legal team, with whom I had the pleasure of working in 2011. I am specifically grateful to John Shurts for reviewing the legal sections of this paper for accuracy.

the *implied reserved water rights* held by Federal tribes in that it established that reservations were created with water rights sufficient to provide "enough water to irrigate their lands and make the reservation viable and productive" (Pevar 2002, p.240). However, the unique legal context of Alaska means that it is unlikely that *Winters Doctrine* can be applied.

The Alaska Native Claims Settlement Act (ANCSA), passed by an Act of Congress in 1971, is the most influential legislation affecting indigenous peoples in Alaska. Consequently, it is the starting point for a discussion on indigenous water rights. ANCSA consisted of a cash settlement of $962.5 million and 44 million acres of land, meaning that the remaining lands in Alaska were ceded for three dollars an acre. The settlement also resulted in the creation of thirteen regional and many more village corporations to administer these claims (Berger & Alaska Native Review Commission 1985). Section 4(b) of ANSCA explicitly extinguished all aspects of aboriginal title:

> (b) All aboriginal titles, if any, and claims of aboriginal title in Alaska based on use and occupancy, including submerged land underneath all water areas, both inland and offshore, and including any aboriginal hunting or fishing rights that may exist, are hereby extinguished.
>
> (c) All claims against the United States, the State, and all other persons that are based on claims of aboriginal right, title, use or occupancy of land or water areas in Alaska, or that are based on any statute or treaty of the United States relating to Native use and occupancy, or that are based on the laws of any other nation, including any such claims that are pending before any Federal or state court or the Indian Claims Commission, are hereby extinguished. (US Public Law 92-203 1971)

Although the courts have never analyzed the issue of native water rights directly, ANSCA is fairly explicit regarding the extinguishment of aboriginal title including water rights. It can be argued that the succession of water rights is implied within the

extinguishment of title to land. The potential for the recognition of indigenous water rights is complicated by the legal decision in *State of Alaska v. Native Village of Venetie* that ruled the lands held in fee simple by native corporations is not "Indian country" (Carpenter 1999).[23] In this context, where tribal governments are nothing more than a collection of people, unconnected to a land base, it becomes difficult to make a *Winters Doctrine* type argument. One possibility for addressing indigenous water rights in Alaska would be to re-open ANSCA in order to clarify the existence of water rights. However, this is a long-term legal solution and there are many barriers to its realization.

Subsistence rights in Alaska provide an alternative avenue for recognizing indigenous water rights. ANSCA also included a vague promise that indigenous subsistence rights would be protected. This protection was not realized until 1980 with the passage of Alaska National Interest Land Claims Act (ANILCA), designed to promote subsistence rights to wild resources over recreational and commercial uses on federal lands (Wheeler & Thornton 2005). Title VIII of ANILCA creates a rural subsistence priority, which means that subsistence rights are not exclusive to Alaska Natives. Instead they are granted on the basis of rural residency. Although ANILCA acknowledges the importance of subsistence rights for cultural existence and therefore includes allowances to include hunting and fishing for 'customary and traditional uses' (Congress 1980; Berger and Alaska Native Review Commission 1985). The

[23] Native corporations are the holders of fee simple title to the lands retained by native peoples after ANCSA, entitling them to the same ability to file for water rights as any other private landowner in the State of Alaska, where water is managed on the basis of the doctrine of prior appropriation.

possibility of protecting waters pertinent to subsistence uses has been argued using ANILCA.

Federal reserved water rights represent an alternative avenue for protecting indigenous water rights in Alaska. The *reserved water rights doctrine* is an extension of the *Winters Doctrine* that asserts water rights are reserved through the creation of federal lands,[24] and include protection of both instream and out-of-stream uses.[25] In Alaska, it has been argued that federal reserved water rights were implied in the creation of title VIII public lands. However, the extent of these water rights hinges on the much debated definition of 'public lands'; the subject of the *Katie John* legislation. ANILCA defines federal public lands as "those lands, waters, and interests therein" (Congress 1980). The federal government initially asserted that title VIII applied to federal lands and not waters. Beginning in 1990, the *Katie John* legislation has discussed "whether navigable waters fall within the statutory definition of public lands and are thus subject to federal management to implement ANILCA's subsistence priority" (F. 3d 1995). The U.S. federal government supported the view that public lands include waters. However, the State of Alaska views this as a challenge to state sovereignty over navigable waters, such as the Yukon River, to which they hold title (Nockels 1996).[26] In an initial ruling, the courts decided that federal reserved water

[24] http://dnr.alaska.gov/mlw/water/fedrsrv.htm

[25] Instream uses refer to water use that takes place within the stream channel. For example, hydroelectric power generation, fish propagation and use, navigation and recreation. In contrast, out-of-stream uses include those uses, which remove water from the stream channel including irrigation and other agricultural uses, the supply of domestic drinking water systems and other.

[26] Katie John is an Athabascan elder from Mentasta, who along with other villagers fished at the convergence of the Copper Rivera and the Tanada Creek at a traditional fish camp called Batsulnetas, which is now located in Wrangell-St. Elias National Park in Southcentral Alaska.

rights exist in Alaska and but these rights have yet to be defined. The federal government reissued regulations pertaining to the scope, extent and purpose of water rights in or adjacent to federal land reserve for the purpose of fulfilling the subsistence priority assured by ANILCA title VIII. This definition extends reserved water rights to waters adjacent to as well as downstream from federal reserves. The federal governments definition is currently being litigated before the Ninths Circuit Court of Appeals (F. 3d 2001). While the *Katie John* legislation argues that the federal governments definition is too narrow and asserts federal reserved water rights should extend to all navigable waters upstream and downstream from federal reserves, the State of Alaska claims that if reserved water rights exist, they should only pertain to waters directly adjacent to federal reserves. While it will be several years before a decision is reached, federal reserved water rights offer a possible means of protecting water quality, quantity and rate of flow necessary to protect subsistence uses of water resources including habitat for subsistence species of fish and wildlife critical to the way of life for the people of Ruby and other native tribes.

Water rights are essential to the ability of the people of Ruby to maintain their relationship to water including but not limited to the various subsistence activities that are pertinent to maintaining their way of life. This brief summary of indigenous water rights in Alaska reveals more questions than answers. The current state of indigenous water rights in Alaska and future steps towards asserting these rights requires further attention from legal experts. At the same time, it must also be recognized that

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The state closed all fisheries on the Copper River in 1964, only permitting Katie John and others to fish the smaller tributaries of the Copper River, which provide insufficient habitat to meet the nutritional and cultural needs of these rural residents (Nockels 1996).

indigenous water sovereignty is not solely achieved through the acknowledgement legal rights to water. The following section elaborates on the role of cultural choice, ecological knowledge, ecological possibility in the assertion of water sovereignty.

Cultural choice relates to indigenous peoples' ability to maintain relationships to water and other elements of their environment (Wilson et al. 2011). Relations to water are exemplified by the uses of water outlined above (Table 4). Cultural choice is the ability to use or relate to specific bodies of water (*context specificity*), based on diverse values that are central to cultural relations to water (*complex connectivity*). Furthermore, cultural choice is not static; relations to water are based on inherited traditions that are passed down through generations, but these relations also evolve overtime (*dynamic and adaptive*). Cultural choice occurs at multiple scales and can vary within communities, between families and individuals (Wilson et al. 2011). Cultural choice implies that the possibilities available for indigenous peoples to relate to water must be relevant to their specific socio-cultural and ecological relations.

In Ruby Village, cultural choice includes the ability to maintain relations to water essential to subsistence livelihoods and beyond. The use of diverse sources of drinking water is one element of subsistence. Research findings indicate that social changes such as sedentization and the introduction of a private wells and municipal water supply in the early 1980s have led to increased reliance on groundwater. However, increased reliance on other sources of water does not negate the importance of other sources of drinking water, including the Yukon River, its tributaries and springs. These water sources continue to be used today, especially when people are out on the land engaged in subsistence hunting, fishing and trapping. In many cases these

traditional water sources, especially springs are preferred to the municipal drinking water because they are considered healthier and do not contain the strong taste that accompanies chlorination. From a water security perspective, the provision of treated drinking water from the municipal water supply may be adequate to meet the basic water needs of the people of Ruby. However, this perspective fails to consider the continued cultural importance of other drinking water sources.

Ecological knowledge is pertinent to the capacity to exercise water sovereignty (Kassam et al. 2010; Wilson et al. 2011). Ecological knowledge is generated through indigenous peoples' long-term use and occupancy within a given territory. Through dynamic practices, the holders of this knowledge adapt to social and ecological change (Berkes et al. 2000). The ability to relate to water is not only made possible through the recognition of water rights by colonial states, but also depends on the presence of ecological knowledge that is the basis for diverse uses of water. Ecological knowledge can also include of scientific knowledge and methods necessary to understanding how changes in the environment are impacting indigenous peoples relations to water.

In Ruby Village, ecological knowledge informs all relations to water. It is required in order to safely travel on the Yukon River during times of open water and when it is frozen over during the winter months, to obtain safe drinking water from a variety of sources and to fish for salmon and other subsistence species in a diversity of habitats. Indigenous knowledge has enabled observations of hydrologic change including alterations in water resources as a consequence of climate change and environmental degradation in the landscape surrounding Ruby Village.

Hydrologic changes and their impacts on subsistence livelihood practices are challenging indigenous knowledge holders to adapt their practices in response to threats to health, safety and access. Through working with the Yukon River Inter-Tribal Watershed Council (YRITWC) and other organizations, scientific methods are also being employed alongside indigenous knowledge in the community to better understand these hydrologic processes. Combining indigenous and scientific knowledge can contribute to more effective responses in the face of unprecedented change (Kassam 2009). For example, the use of water quality sampling may reveal important information about the influence that climate change and contaminants are having on water resources that may not otherwise be detected by community members. In this sense, scientific knowledge is complimentary to the indigenous knowledge of water resources maintained by the people of Ruby. Scientific knowledge can therefore be considered part of the ecological knowledge necessary to assert water sovereignty.

Ecological possibility is another vital element of water sovereignty. Ecological possibility refers to the continued health of the environment necessary for people to maintain their relations to water resources (Wilson et al. 2011). Water rights are irrelevant in contexts where water resources are so degraded that it is no longer an option to use them in a manner consistent with their chosen socio-cultural and ecological relations. In Ruby Village, the relatively unimpaired water quality and quantity of the Yukon River and its tributaries support the continued ecological possibility necessary for the practice of subsistence livelihoods. However, hydrologic changes driven by climate change and environmental degradation including

contamination contributed from municipal, mining and military waste threaten this currently pristine state. The assertion of water sovereignty therefore also encompasses actions taken to maintain or restore degraded waters such that the ecological possibility to use these waters exists.

The boundary crossing nature of water resources requires illustrates the relational nature of sovereignty. Water resources are characterized by their location within open systems, for example the people of Ruby's relationship to water is influenced by both upstream and downstream factors within the YRB, making it difficult, if not impossible to have complete control over water resources at the local level. However, the notion of sovereign interdependency illustrates that the challenges water resources pose to modern notions of sovereignty as independence are not unique (Cattelino 2010). The boundary crossing nature of water not only causes us to think about the potentially antagonistic relationships that can result from the inability for states or local communities to fully control water resources, it also shows us how the assertion of water sovereignty is in fact dependent on cooperation between states, federal governments and indigenous peoples.

Indigenous peoples in the YRB demonstrate the potential for the assertion of water sovereignty through cooperation as they working with the YRITWC and other organizations to address current threats to water resources. The YRITWC – a grassroots organization based on a treaty between 70 indigenous governments from Yukon Territory and British Columbia, Canada and Alaska, USA – exemplifies the potential for an indigenous institution to support the assertion of water sovereignty by individual native tribes and First Nations. They seek to achieve their mission "to

initiate and continue the clean up and preservation of the Yukon River for the protection of our own and future generations of our Tribes/First Nations and for the continuation of our traditional Native way of life."[27] Through various environmental programs and projects, they combine indigenous and scientific knowledge, through the practice of 'traditional science,' in order to respond to the threats posed by climate change and environmental degradation in the YRB. The YRITWC's basin-wide water quality study – an ongoing collaborative study that began in 2000, carried out by the YRITWC, with support from 70 indigenous governments and the USGS – is aimed at addressing community concerns related to contaminants and climate change.[28] Furthermore, this work lead to the creation of an Indigenous Observation Network (ION) aimed at understanding the impacts of climate change in the YRB through which they have established "39 fixed station water quality sites, 11 (soon to be 20) active layer observation grids (ALN), trained 100+ local technicians and directly involve 23 indigenous governments."[29] This work represents an effort to assert cultural choice, ecological knowledge and maintain or restore ecological possibility through the protection of the waters of the YRB and the indigenous peoples who reside there. The work of the YRITWC and other similar organizations can contribute to the assertion of water sovereignty by individual Alaska Native Tribes and First Nations

[27] www.yritwc.org
[28] The YRITWC is funded by a variety of sources including Yukon Territory Government, the Northern Strategies Trust, The Administration of the Native Americans, The United States Geological Survey, National Science Foundation, Environmental Protection Agency IGAP, Alaska DEC and National Weather Service. http://www.yritwc.org/Departments/Science.aspx
[29] http://www.yritwc.org/Departments/Science/Indigenous_Observation_Network_History.aspx

and facilitate the formulation of collective responses the watershed scale to mitigate or adapt to the impacts of alterations in water resources.

***Conclusion and Recommendations***

This paper develops the concept of water sovereignty for the purpose of understanding and protecting indigenous peoples socio-cultural and ecological relations to water. Research findings show that the people of Ruby maintain distinct relations to water, which are *context specific*, *complex connectivity* and *dynamic and adaptive*. These socio-cultural and ecological relations to water are fundamental to both their material and cultural survival as indigenous peoples. The people of Ruby's the relationship to the Yukon River, its tributaries and associated aquifers reveals the need to go beyond the basic needs approach to water implicit in the concept of water security. Building on research findings and a burgeoning food sovereignty literature, water sovereignty is defined as *the rights and possibility of individuals and groups to define their own relationship to water in a manner consistent with the socio-cultural and ecological systems they inhabit.* Water sovereignty encompasses the protection of various uses of water and ways of relating to specific bodies of water, which are intimately a part of a way of life maintained by indigenous peoples within their traditional territory and affected by hydrologic processes at larger ecological scales.

Current threats to water resources in Ruby Village, the Yukon River Basin and many other regions around the globe at once highlight the urgency for developing a concept of water sovereignty and the challenges presented by these threats to its assertion. Climate change is perhaps one of the greatest threats to indigenous water sovereignty in the YRB. Indigenous peoples are among the most affected by global

climate change, yet they have limited control over its root causes. Many indigenous peoples are excluded from accessing the political and legal mechanisms available to national governments and international organizations aimed at reducing greenhouse gas emissions (GHGs). However, the slow pace at which proposals to reduce GHG emissions, the root cause of climate change and evidence suggesting that climatic change is accelerating provides limited hope for mitigation (Adger et al. 2005; Smit et al. 2000). The reality of climate change leaves more questions than answers as we seek to understand how best to support indigenous communities to adapt in a changing context. The work of indigenous institutions such as the YRITWC offers some insight into the types of responses that individual communities are formulating locally and in this case collectively, at the watershed scale. Furthermore, academic researchers have an ethical responsibility to structure applied research in a manner that supports these efforts. This research project tries to exemplify how research can be designed in a way that takes this responsibility seriously. Specifically, Participatory Action Research (PAR) fundamentally this research project, which was conducted in collaboration with local institutions, the YRITWC and the Ruby Tribal Council, in order to contribute to the formulation of strategies to address the current threats to water resources in the YRB. While the design of this research project does not perfectly achieve the ideal of PAR, it represents an example on which future research projects can build.

This paper explores the requisite rights and possibilities for asserting water sovereignty. While legal recognition of water rights is important, they not the only element required for the assertion of water sovereignty. Without the existence of

cultural choice enabled by ecological knowledge and ecological possibility, water rights are meaningless. Furthermore, the assertion of sovereignty can be possible even in the absence of legally recognized indigenous water rights. For example, the people of Ruby Village, collectively with other Alaska Natives and First Nations from the Yukon River Basin, have significant political influence. Examples from the Canadian context set a precedent for the achievement of co-operative agreements that include indigenous peoples in water management and governance processes, even in the absence of defined water rights or jurisdictional authority (Phare 2009). According to Merrell-Ann Phare – a Canadian lawyer specializing in First Nations water law, "[a]ll it takes now is the decision to pull some extra chairs to the table" (Phare 2009, p.79). Future research on water sovereignty should explore the potential for indigenous peoples in the YRB to assert themselves into water governance processes as co-equal sovereigns along with state, territorial and federal governments. Given the transboundary nature of the Yukon River Basin and the complex jurisdictional reality that often characterizes transnational watersheds, extensive research and consultation will be required to understand the best way for indigenous governments to take on an explicit and recognized role in water governance.

Further case studies examining the human ecology of water of indigenous peoples in other regions of the world are required to strengthen the argument for water sovereignty. Applied research, in conjunction with local institutions should be conducted with the goal of contributing to the formulation of pragmatic responses to context specific challenges to water sovereignty. Furthermore, the similarities between indigenous peoples' relations to water demonstrated by additional case studies may

also contribute to a general understanding of how local communities are responding to threats to water resources globally. Case studies of water sovereignty should be focused in regions affected by high water stress including those experiencing the most extreme effects of climate change and those facing the dramatic consequences of development such as the construction of dams and or the development of mining industries on water quality, quantity and rate of flow.

# CONCLUSION

The chapters contained within this thesis illustrate the value of human ecology for understanding the complex relationships between indigenous peoples and their ecologies. Human ecological relations to plants, animals and 'abiotic' elements of the environment allow us to understand dimensions of the diverse and multifaceted relations between humans and their environment. This perspective represents a way to approach diverse issues affecting indigenous peoples and the potential impacts these changes might have on their the socio-cultural and ecological system they inhabit. The value of this approach is seen through the individual chapters of this thesis.

Chapter 1 demonstrates the role of human ecological approaches to understanding how indigenous knowledge can contribute to understandings of the impacts of change on the hydrology of the Yukon River. Specifically, the concept of *Phronesis*, as conceptualized through human ecology is useful as the basis for understanding how indigenous knowledge is generated and integrated with scientific knowledge in the same process iterative process of knowledge generation. Community experts observed a number of the changes in hydrology of the Yukon River including alterations in river ice and sediment regimes are not adequately explained in the scientific literature. These observations merit further investigation both because of their importance for improving scientific understandings of climate change and because it may contribute insights useful to local communities in the formulation of mitigation and adaptation strategies.

Chapter 2 shows the value human ecological research for understanding the ethical dimensions of adaptation to climate change. This paper documents changes in

the human ecology of the people of Ruby Village, resulting largely from colonization, by comparing past and present subsistence practices. Research findings demonstrate that a historical perspective on adaptation is essential to understanding the influence of the current political context on the ability of indigenous peoples to adapt to the impacts of climate change.

Chapter 3 highlights the contribution of human ecological research to understanding and protecting the unique relationships between indigenous peoples and water. The concept of water sovereignty is firmly rooted in human ecology. This perspective demonstrates that, in addition to recognized legal rights, culturally relevant opportunities, ecological knowledge and ecological possibility are requisite elements for the assertion of water sovereignty.

Combined, these three chapters demonstrate the importance of a participatory research approach. Using a participatory approach has reinforced my belief that research is fundamentally about relationships. The many relationships built in the course of this research project were essential to my success. These include my engagement with the YRITWC and the Ruby Tribal Council and the individual community experts who contributed their knowledge to this research. Relationships are fundamental to making researchers accountable to the communities where they work. This is true because it requires researchers to validate the results of their research and to structure their inquiry in such a manner that the outcomes are meaningful to participating communities. It is my sincerest hope that the results of this research are meaningful to my research partners, RTC and the YRITWC and to the people of Ruby Village. The YRITWC has indicated that the findings of my

research are useful to them in guiding their future research foci specifically related to indigenous knowledge and understanding hydrologic change in the YRB. Furthermore, the RTC has specifically indicated that the project is a valuable for its documentation of the many historical changes that have taken place in Ruby Village from the perspective of its indigenous residents. Finally, the relationships built during this participatory research project will have value beyond the life of individual research projects. Though my thesis is now complete my engagement with the YRITWC, the RTC and individuals from Ruby Village promise to endure into the future.

APPENDIX A

OVERVIEW OF RESEARCH DATA

| Community Expert | Interview Details | Mapping | Seasonal Round |
|---|---|---|---|
| **George Albert** | Conducted: September 30th, 2010<br>Validated: October 4th, 2010<br>Follow-up Interview: July 12th, 2011 | Yes | Yes |
| **Phillip Albert** | Conducted: August 5th, 2010<br>Validated: October 12th, 2010 | Yes | No |
| **Tom Esmailka** | Conducted: August 6th, 2011<br>Validated: August 8th, 2011 | Yes | Yes |
| **Alfred & Karen Gurtler** | Conducted: Sunday August 1st, 2010<br>Validated: September 23rd, 2010<br>Follow-up Interview: July 10th, 2011 | Yes | Yes |
| **Clara Honea** | Conducted: August 3rd, 2010<br>Validated: September 24th, 2010<br>Follow-up Interview: July 12th, 2011 | Yes | Yes |
| **John William (Billy) Honea** | Conducted: August 8th, 2010<br>Validated: September 26th, 2010<br>Follow-up Interview: July 15th, 2011 | Yes | Yes |
| **Lorraine Honea** | Conducted: August 2nd, 2010<br>Validated: September 24th, 2010 | No | No |
| **Nora Kangas** | Conducted: August 4th, 2010<br>Validated: Sept 22nd, 2010 | No | No |
| **Billy McCarty** | Conducted: August 5th, 2010<br>Validated: September 27th, 2010<br>Follow-up Interview: July 18th, 2011 | Yes | Yes |
| **Emmitt & Edna Peters** | Conducted: August 1st, 2010<br>Validated: September 23rd, 2010<br>Follow-up Interview: July 15th, 2012 | Yes | Yes |
| **Joseph Peters** | Conducted: August 1st 2011<br>Validated: August 6th, 2011 | Yes | Yes |
| **Mark & Tudi Ryder** | Conducted: July 14th, 2011<br>Validated: August 2nd, 2011 | Yes | Yes |
| **Ed Sarten** | Conducted: October 5th, 2010<br>Validated: October 12th, 2010<br>Follow-up Interview: July 13th, 2011 | Yes | Yes |
| **Lily Sweetsir** | Conducted: August 5th, 2010<br>Validated: September 27th, 2010 | Yes | Yes |
| **Pat Sweetsir** | Conducted: October 5th, 2010<br>Validated: October 15th, 2010<br>Follow-up Interview: July 15th, 2011 | No | No |
| **Allan Titus** | Conducted: July 18th, 2011<br>Validated: August 7th, 2011 | Yes | No |
| **Martha Wright** | Conducted: August 7th, 2010<br>Validated: October 1st, 2010<br>Follow-up Interview: July 14th, 2011 | Yes | Yes |

APPENDIX B

ATTRIBUTES OF INDIGENOUS KNOWLEDGE

| Attributes of Indigenous Knowledge | |
|---|---|
| **Context Specific** | Indigenous knowledge is context specific or ”related to, and contained within, a group of people who live in a defined geographic region. Indigenous knowledge includes a web of relationships between humans, animals, plants, natural forces, spirits, and land forms” (Kassam 2009a: 85). |
| **Complexly Connected** | Indigenous knowledge “arises from closeness to the land and the relationships with living things. In this sense, it grows out of a connection to the natural surroundings. It is obtained by the labour of living and experiencing the context, and not through book-learning. Indigenous knowledge is derived from a sense of kinship with or, more accurately, a kindred spirit with other living creatures, the land, the sea, and the spirit worlds. Knowledge in this context is derived fundamentally from the environment. As a result of the kindred spirit there is no separation between the biotic and abiotic or between renewable and non-renewable.” (Kassam 2009a: 85). |
| **Empirical Tendency** | Indigenous knowledge is “observational, analytical, practical, and effective. Rather than exploring the biochemical or physiological makeup of plants and animals, it provides responses to such questions as: where are they found, what methods may be used to harvest them, and how can they be utilized?” (Kassam 2009a: 86-87). |
| **Cumulative** | Indigenous knowledge holders tend to be “conscious not only of the wisdom and observations of their generation but of the generations that preceded them. This does not mean that tradition is fixed in a particular time or age. In fact, it is dynamic and adaptive. The holders of the knowledge do not only have a perception of the pastness of the past, but also its presence. New ideas and approaches are quickly adopted if they are seen to benefit people. (Kassam 2009a: 87-88). |
| **Plural** | Indigenous knowledge, “like many other knowledge systems, is sufficiently complex that it does not lend itself to terse and easy characteristics. […] The degree to which an individual within a group may hold this knowledge varies with age, gender, social class, level of experience, linguistic ability, access to oral tradition, and even interest in the subject” (Kassam 2009a: 88). |

APPENDIX C

DESCRIPTION OF FOURTEEN SUBSISTENCE LIVELIHOOD ACTIVITIES IN RUBY VILLAGE, AK

| **Description of Fourteen Subsistence Activities in Ruby Village, AK** | | |
|---|---|---|
| **Livelihood Activity**[30] | **Description** | **Species Names (Common, Scientific & Koyukon)**[31] |
| **Moose Hunting** | Moose hunting is one of the most important subsistence activities for the people of Ruby. It is both a culturally-important activity and moose meat comprises a large proportion of their diet (Brown et al. 2004). | Moose (*Alces alces*): *Deneega* |
| **Fishing** | Fishing is one of the most important subsistence activities. Salmon provide one of the most important subsistence sources of food. Salmon fishing occurs between the end of June and the end of September and many people still maintain a fish camp. Other fish are caught throughout the year. However, the spring camp where much of this fish was caught is not longer practiced. | Alaska blackfish (*Dallia pectoralis*): *oonyeeyh*<br>Burbot, loche, ling cod (*Lota lota*): *tl'eghes*<br>Dolly Varden trout (*Salvelinus malma*, uncertain identification): *ggaal yeega', silyee lookk'a*<br>Grayling (*Thymallus arcticus*): *tleghelbaaye*<br>Longnose sucker (*Catostomus catostomus*): *bedleneege toonts'oode*<br>*Northern Pike (Esox lucius): K'oolkkoye*<br>Salmon (any kind): l*ookk'e*<br>Chinook or King Salmon (*Oncorhynchus tshawytscha*): *ggaal*<br>Chum or Dog Salmon (*Oncorhynchus ketaII*):<br>Summer-run Chum salmon: *noolaaghe*<br>Fall-run chum salmon: *noldlaaghe*<br>Silver or Coho Salmon (*Oncorhynchus kisutch*): *leghaane*<br>*Sheefish, inconnu (Stendous leucichthys nelma): ledlaaghe*<br>Whitefish (any kind): *look'e* |

[30] Livelihood activities were borrowed from (Nelson 1986) and adapted to the context of Ruby Village.

[31] All Koyukon names taken from The Koyukon Athabascan Dictionary authored by Eliza Jones and Jules Jetté (2000).

| | | |
|---|---|---|
| **Bear Hunting** | Bears are hunted for their skins and meat. Bear hunting is traditionally only done by men and takes place at various times of the year. Bears are considered, *Hutlanee* Animals (Taboo)**,** which have very strong spirits. | American Black Bear (*Ursus americanus)*: *ses*<br>Grizzly or Brow*n Bear* (*Ursus arctos*): *tlaaghoze* |
| **Fur Animal Hunting and Trapping** | Trapping usually starts in November when the snow falls and ends in March or April at the end of the beaver season.<br>Marten, mink, fox, lynx, wolves, wolverine, beaver and muskrat are all trapped for their furs and in some cases for meat. Furs are either used locally or sold to fur traders. Although there are fewer people who actively participate in trapping, it continues to be an important activity. | Marten (*Martes Americana*): *sooge*<br>American Mink (*Neovison vison*): *taahgoodze* Literally: 'under water'<br>Red Fox (Vulpes fulva): *naaggedle*<br>Lynx (*Lynx canadensis*): *kaazene* lit: 'black tail'<br>Wolverine (*Gulo luscus*): *neltseel*, *doyonh*<br>Wolf (*Canis lupus*): *nek'eghun, tookkone*<br>Muskrat (*Ondatra zibethicus*): *bekenaale*<br>Beaver (*Castor canadensis*): *noye'e, ggaagge* |
| **Snowshoe Hare Hunting and Trapping** | Rabbit snaring begins in late November or early December when the snow has fallen and the rabbits have changed color. There is no closed season and no harvest limit. Rabbits are snared for their meat and fur. Their fur is used to make mittens and other articles of clothing. | Snowshoe Hare (*Lepus americanus):*<br>*White in winter: gguh*<br>*Brown summer coat: saanh zooge* |
| **Waterfowl Hunting** | People hunt waterfowl such as ducks, geese and swans when they return in March until break-up occurs on the Yukon River. They are hunted again after break-up when go out on the river in their boats. People make sure to stop hunting them in June when they are breeding. Specific trips to hunt these birds are not made often. They are hunted in the course of other subsistence activities such as moose hunting. | Common Loon (*Gavia immer*): *dodzene*<br>Goose (general term): *dets'ene*<br>Canada Goose (*Branta Canadensis): belaalzene*<br>Snow Goose (*Chen hyperboreus*): *hugguh*<br>Duck (general term): *nendaale*<br>Sandhill Crane (*Grus Canadensis): deldoole*<br>Swan (*Cygnus sp.*): *toyene*<br>Trumpeter swans (*Cygnus buccinator*)<br>Tundra swans (*C. columbianus*) |

| | | |
|---|---|---|
| **Spruce Grouse Hunting** | Spruce grouse or spruce hens can be hunted as early as mid-August and can be hunted until mid-April. However, most people hunt them from September until it snows in November, because after a certain time their meat begins to taste like spruce. | Spruce Grouse (*Canachites canadensis): deyh* |
| **Willow or Ruffed Grouse Hunting** | Willow grouse (Ruffed grouse) can be hunted from August until about mid-April. Most people hunt them in the fall between September and November, when the snow falls. Some people begin hunting them again in January and February. Some people said that they have the same season as Spruce grouse, while others stated that they hunt Willow Grouse later into the season. | Willow Grouse *(Bonasa umbellus)*: *tsonggude* |
| **Ptarmigan hunting** | Ptarmigan live in the tundra of the high Arctic in the summer months and migrate south to the forest for the winter months. It is possible to hunt these from late November or early December until the end of February. | Willow Ptarmigan Hunting (*Lagopus lagopus*): *daaggoo*<br>Rock Ptarmigan (*Lagopus muta*): *daak'aa* |
| **Berry Picking** | The people of Ruby pick many kinds of berries during the summer and fall months. Berries are eaten fresh, made into fish ice cream, made into baked goods or preserved as jam. | Bog cranberry (*Oxycoccuss microcarpus*): *daal nodoodle*'<br>Highbush cranberry (*Viburnum edule*): *donaaldloye*<br>Lowbush cranberry (*Vaccinium vitis*): *denaalekk'eze*<br>*Crowberry, blackberry (Empetrum nigrum): deenaalt'aas*<br>Red Currant (*Ribes triste*): *notsehtl'oone*<br>Black Currant (*Ribes hudsonianum*): *dotson' geege'* |

| | | |
|---|---|---|
| | | Raspberries (*Rubus idaeus*): *dets'en tl'aakk*<br>Rosebuds (*Rosa acicularis*): *kooyk*<br>Salmonberry, cloudberry (*Rubus chamaemorus*): *kkotl*<br>Wild rhubarb (*Polygonum alaskanum*): *ggool* |
| **Wood Cutting** | Wood is cut or collected for various uses including firewood and to build traditional snowshoes and sleds. | American Green Alder (*Alnus crispa*): *kk'es*<br>Balsam poplar (often mistakenly called cottonwood poplar) *(Populus balsamifera): t'eghel*<br>White spruce (*Picea glauca*): ts'ebaa<br>Black spruce (*Picea mariana*): *ts'ebaa t'aal*<br>Paper Birch (*Betula papyrifera*): *kk'eeyk*<br>Quaking aspen (Populus trichocarpa): *t'eghel kk'ooge*<br>Willow (general term): *kk'uyk* |
| **Gardening** | Gardens have been cultivated in Ruby since the early 20th century. At the time this research was conducted, 11 out of 62 households had a small garden. There is also a community garden that being used primarily to teach children about gardening | A variety of vegetables are cultivated including potatoes, turnips, carrots, strawberries, tomatoes, rutabaga, cabbage, and lettuce |
| **Wage Labour** | The economy of Ruby can be characterized as a 'mixed' economy, where cash is an important input into subsistence livelihoods (Wenzel et al. 2000). | A variety of seasonal and year round jobs are held in industries including carpentry, construction and firefighting. |
| **Caribou Hunting** | There are caribou from the Western Arctic Herd in the Kilbuck-Kuskokwim Mountains near Ruby. The people of Ruby used to hunt caribou, but this is not practiced anymore. | Caribou (*Rangifer tarandus granti): bedzeeyh* |

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